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ENVIRONMENTAL EVALUATION WORK PLAN (EEW) OPERABLE UNIT NO. 2 (903 PAD, MOUND, AND EAST TRENCHES AREA)

U.S. Department of Energy
Rocky Flats Plant
Golden, Colorado

ENVIRONMENTAL RESTORATION PROGRAM

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LIST OF ACRONYMS AND ABBREVIATIONS

ARARS	Applicable or relevant and appropriate requirements
BCF	Bioconcentration factor
bw	body weight
C	Carbon
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHWA	Colorado Hazardous Waste Act
Cl	Chlorine
CNS	Central nervous system
DOE	U.S. Department of Energy
DOW	Division of Wildlife
DQO	Data quality objective
EE	Environmental evaluation
EER	Environmental Evaluation Report
EEW	Environmental Evaluation Workplan
EPA	Environmental Protection Agency
ER	Environmental Restoration
FFCA	Federal Facility Agreement and Consent Order (Agreement)
FS	Feasibility study
H	Hydrogen
Hg	Mercury
IAG	Interagency Agreement
IHSS	Individual Hazardous Substances Site
JTS	Job Tracking System
kg	kilogram
K_{ow}	Octanol-water ratio
l	liter
m	meter
mg	milligram
mm	millimeter
NCI	National Cancer Institute
NCP	National Oil and Hazardous Substances Contingency Plan
NEPA	National Environmental Policy Act
NOEL	No observed effect level
OSHA	Occupational Safety and Health Administration
OU	Operable unit
PCE	Tetrachloroethylene
PPE	Personal protective equipment
ppm	parts per million
QA	Quality assurance
QAPP	Quality Assurance Program Plan
QATP	Quality Assurance Task Plan
QC	Quality control
RCRA	Resource Conservation and Recovery Act

RFD	Reference dose
RFI	RCRA facility investigation
RFP	Rocky Flats Plant
RI	Remedial investigation
SARA	Superfund Amendments and Reauthorization Act
SPP	Super Project Planner
SWMU	Solid waste management unit
TCE	Trichloroethylene

EXECUTIVE SUMMARY

The Environmental Evaluation Work Plan (EEW) has been prepared for Operable Unit (OU) No. 2 (903 Pad, Mound, and East Trenches Area) at the U.S. Department of Energy (DOE) Rocky Flats Plant (RFP) which is situated northwest of Denver, Colorado. The EEW is based on:

- The Environmental Protection Agency's (EPA's) mandate under the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA" or "Superfund") to protect human health and the environment from actual or threatened releases of hazardous substances
- The requirement of the National Oil and Hazardous Substances Contingency Plan (NCP) to perform "environmental evaluations" at CERCLA sites in order to assess threats to the environment
- The EPA Risk Assessment Guidance for Superfund Volume II Environmental Evaluation Manual (EPA, 1989b)
- The Federal Facility Agreement and Consent Order entered into between the DOE, EPA Region VIII, and the State of Colorado, also known as the Interagency Agreement (IAG), which requires the DOE to perform environmental response activities at the RFP that are consistent with the requirements of CERCLA and other applicable federal and State laws and regulations.

The EEW described in this volume provides a generalized overview of the RFP, establishes environmental evaluation (EE) purposes and objectives, details an environmental evaluation methodology, and identifies specific tasks to be undertaken as part of the EE implementation process. Appendix C of the document contains a Field Sampling Plan (FSP) which describes a comprehensive program for sampling and analysis of biological resources and ecosystems within and near OU No. 2 in order to assess potential ecological consequences of releases of contaminants from the 903 Pad, Mound, and East Trenches Area.

A Phase I remedial investigation (RI) has been conducted for OU No. 2 in order to gain site specific information on soils, ground water, and surface water (Rockwell International, 1987). The planned Phase II RCRA Facility Investigation/Remedial Investigation and

Feasibility Study (RFI/RIFS) will include a baseline risk assessment comprised of two parts: a human health risk assessment and an environmental evaluation (or ecological risk assessment). In this context, the EEW is integral to the Phase II RFI/RIFS work plan.

The EEW describes the process by which potential environmental risks deriving from existing OU No. 2 conditions will be assessed, relying in part on data collected during the Phase I and Phase II RFI/RIFS. When the EEW is implemented, it will characterize the levels and toxicity of hazardous substances present in the environment, the fate and transport of contaminants, and the potential for exposure of contaminants to plants and animals. The EE approach has much in common with human health risk assessments in that the same basic steps are employed: contaminant identification, exposure assessment, toxicity assessment, and risk characterization. The process is illustrated in Figure 2 of the EEW. The major guidance document that will be relied upon in implementing the EEW is the EPA Environmental Evaluation Manual (EPA, 1989b).

The principal focus of the EEW is on an environmental evaluation methodology which is described in detail in Section 2.0. The basic methodological components addressed are:

1. Data evaluation and analysis
2. Environmental analysis (ecosystem characterization, field investigations, and exposure pathway analysis)
3. Toxicity assessment which estimates exposure and dose or major ecological consequences using specific ecological endpoints
4. Risk characterization based on the environmental analysis, exposure pathway assessment, and toxicity assessment.

The overall purpose of the OU No. 2 EE is to document a qualitative and, where possible, a quantitative assessment of actual or potential threats of damage to the environment including wildlife and vegetation species, habitats, and sensitive ecosystems. The EE's multiple objectives are listed in EEW Subsection 1.4.

Although the principal focus of the EEW is on the environmental evaluation methodology detailed in Section 2.0, and the FSP in Appendix C, ten specific tasks under which the EE will be organized, staffed, managed, and performed are identified in EEW Section 3.0. These tasks are as follows:

Task 1 -- Project Organization and Management

Task 2 -- Quality Assurance and Quality Control (QA/QC) Program

Task 3 -- Health and Safety Plan

Task 4 -- Project Documentation

Task 5 -- Scheduling, Costing, and Schedule/Cost Control

Task 6 -- Review of Existing Information

Task 7 -- Data Evaluation and Analysis

Task 8 -- Field Investigations (including Field Sampling)

Task 9 -- Ecological Risk Assessment

Task 10 -- Environmental Evaluation Report

EE program flexibility will be required as the nature and scope of any particular task may need to be modified depending on changes in the existing database, the results of qualitative field surveys, and the data derived from the quantitative field sampling and analysis.

The FSP (Appendix C) will be integrated with the OU No. 2 Phase II RFI/RIFS field sampling program as well as sampling by the Rocky Flats Environmental Monitoring and Analysis Program (EMAP). The sampling procedures discussed have been designed to follow protocols recommended by the EPA and the U.S. Fish and Wildlife Service. Overall objectives of the FSP are to: (1) characterize biological resources in order to conduct the ecological impact assessment, and (2) acquire the data needed to measure the effects of contaminants on ecological systems. Detailed sampling program objectives are listed in Section C.2.0 of Appendix C.

The FSP will consist of both qualitative field surveys and quantitative field sampling. Both programs will identify, characterize and assess aquatic ecosystems (periphyton, benthic macroinvertebrates, and fish) and terrestrial ecosystems (grassland vegetation, small mammals, invertebrates, and wetlands). The FSP also addresses quality assurance/quality control, sample documentation, equipment calibration and checks, health and safety, waste management, sample handling and analytical protocols, and statistical analysis and procedures.

ENVIRONMENTAL EVALUATION WORK PLAN
OPERABLE UNIT NO. 2
903 PAD, MOUND, AND TRENCHES AREAS

1.0 INTRODUCTION

Under §106 of the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA" or "Superfund"), the Environmental Protection Agency (EPA) is mandated by the Congress to take appropriate action whenever "there may be an imminent and substantial endangerment to the public health or welfare or the environment because of an actual or threatened release of a hazardous substance from a facility" (emphasis added). This same language is employed in §104 although the concept of hazardous substance is broadened to include "any pollutant or contaminant." The EPA's mandate to protect human health and the environment is reiterated throughout CERCLA [e.g., §§121(b)(1), 121(c), and 121(d)] and its major implementing regulations which are contained in the National Oil and Hazardous Substances Contingency Plan (NCP) [40 CFR Part 300, Subpart F]. The NCP was extensively revised on March 8, 1990 (55 FR 8666) to incorporate requirements of the Superfund Amendments and Reauthorization Act of 1986 ("SARA"). It provides the overall framework for identifying and obtaining information on hazardous substance sites, assessing the nature and extent of the contamination, determining the risk to human health and the environment, evaluating and selecting remedial action technologies, and implementing decisions on remedial actions.

The requirement for the performance of "environmental evaluations" at CERCLA sites derives from NCP specifications for remedial investigations and feasibility studies (RI/FSs). The regulations in 40 CFR §300.430(e)(i)(G) provide as follows:

> Environmental evaluations shall be performed to assess threats to the environment, especially sensitive habitats and critical habitats of species protected under the Endangered Species Act.

This does not mean that environmental evaluations (EEs) are to be limited to assessing risks to threatened or endangered species of plants or animals.

Detailed guidance on conducting environmental evaluations is contained in the EPA "Risk Assessment Guidance for Superfund Volume II Environmental Evaluation Manual" (EPA, 1989b). Although an "environmental evaluation" is specifically required by the NCP, the EPA uses the term "ecological assessment" as being a more precise description of the activities that actually take place in the environmental evaluation process. The EPA Manual defines an ecological assessment as "a qualitative and/or quantitative appraisal of the actual or potential effects of a hazardous waste site on plants and animals other than people and domesticated species" (EPA, 1989b). The EPA manual recognizes that ecological assessments may identify new or unexpected exposure pathways that may affect human populations.

Ecology is a branch of biological science devoted to the study of the interrelationships between organisms and their environment. In the context of any CERCLA site, human health is inextricably linked to the survival and physiological condition of nonhuman species. Thus, a risk assessment focusing on human health and an ecological assessment are, essentially, different sides of the same coin.

This Environmental Evaluation Work Plan (EEW) has been prepared for operable unit (OU) No. 2 (903 Pad, Mound, and East Trenches Area) at the U.S. Department of Energy (DOE) Rocky Flats Plant (RFP) near Denver, Colorado. The EEW provides a generalized overview of the site, establishes a purpose and objectives, addresses an environmental evaluation methodology, and identifies tasks to be undertaken as part of the environmental evaluation implementation process.

1.1 OVERVIEW OF ROCKY FLATS PLANT AND OPERABLE UNIT NO. 2

The RFP is a government-owned and contractor-operated facility that is part of the nationwide nuclear weapons research, development, and production complex administered by the DOE. The operating contractor for the RFP is EG&G Rocky Flats, Inc. The RFP

produces metal components for nuclear weapons. These components are fabricated from plutonium, uranium, beryllium, and stainless steel. Additional production activities include chemical recovery, purification of recyclable transuranic radionuclides, and metal fabrication and assembly. Other activities include research and development in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics. Weapons parts made at the RFP are shipped elsewhere for final assembly. Plant operations generate nonhazardous, hazardous, radioactive, and radioactive mixed waste streams (Rockwell International, 1987).

The RFP is situated on 6,550 acres of federal property 16 miles northwest of downtown Denver, Colorado. There are 178 Individual Hazardous Substance Sites (IHSSs), also known as Solid Waste Management Units (SWMUs), at the RFP which have been grouped into 16 operable units. OU No. 2 is located on the southeast side of the controlled security area of the Rocky Flats Plant (Figure 1) and consists of 20 IHSSs or SWMUs grouped into three general areas designated as the 903 Pad Area, the Mound Area, and the East Trenches Area (Figure 1).

As part of the Phase II RCRA Facility Investigation/Remedial Investigation and Feasibility Study (RFI/RIFS) to be conducted for OU No. 2, a baseline risk assessment will be performed to provide the basis for whether remedial action under CERCLA is necessary. This baseline risk assessment will be comprised of two parts: the human health risk assessment and the environmental evaluation (or ecological risk assessment). Consequently, this EEW is an adjunct to the Phase II RFI/RIFS work plan.

The EEW prescribes how potential impacts or risks to the environment from existing OU No. 2 conditions will be evaluated, using in part the data collected during the Phase II RFI/RIFS. When the EE is implemented, it will identify and characterize the toxicity and levels of hazardous substances present, the fate and transport of contaminants, and the potential for environmental exposure (to plants and animals).

1.1.1 Rocky Flats Environmental Restoration (ER) Program

The DOE, EPA Region VIII, and the State of Colorado entered into a draft Rocky Flats Federal Facility Agreement and Consent Order (Agreement) (FFCA) in December 1989. The final FFCA, also known as the Interagency Agreement (IAG), is expected to be signed by the agencies in November 1990.

The draft IAG describes the general response processes for hazardous substance sites at the RFP. Environmental response activities performed by the DOE under the IAG are to be consistent with the CERCLA/SARA, the NCP, the Resource Conservation and Recovery Act (RCRA), the Colorado Hazardous Waste Act (CHWA), the National Environmental Policy Act (NEPA), the Atomic Energy Act of 1954, and other applicable federal and State laws and regulations.

The IAG formulates the scope of a phased approach for environmental restoration tailored to meet the specific requirements of the RFP. The environmental response activities under the IAG are managed by the RFP Environmental Restoration Program. The IAG includes a specific response program for each OU as well as a number of site-wide environmental monitoring and response activities. A recent renegotiation of the IAG has resulted in a renumbering of the operable units to reflect the priority of the units in terms of perceptions of potential environmental risks.

In addition to the response activities to be proposed for each OU, there are several site-wide environmental restoration activities which collect information or are otherwise relevant to this EEW:

- Community Relations Plan
- Health and Safety Plan
- Plan for prevention of contaminant dispersion
- Treatability studies
- Quality Assurance Program
- Ground water monitoring program
- Surface water monitoring program
- Baseline wildlife studies
- Background geochemical characterization.

Several other operable units are geographically related to OU No. 2. The drainages downstream of OU No. 2 are separate operable units: Woman Creek, OU No. 5, Walnut Creek, and OU No. 6. An interim remedial action is being planned to treat contaminated surface water in South Walnut Creek north of OU No. 2 (DOE, 1990a). Other operable units which are situated in close proximity to OU No. 2 include the 881 Hillside (OU No. 1) and several SWMUs included in the Other Outside Closures (OU No. 10), the 100 Area (OU No. 13), and the Low Priority Sites (OU No. 16).

A Phase I Remedial Investigation (RI) has already been conducted for OU No. 2, making available site information regarding soils, ground water, and surface water (Rockwell International, 1987). The Phase II RFI/RIFS will emphasize ground water issues and is subdivided into two components: alluvial and bedrock. Available site characterization information on contamination is summarized in the Phase II RFI/RIFS (Alluvial) Work Plan (DOE, 1990a). The Phase II RFI/RIFS (alluvial) will further characterize sources and the extent of contamination in the uppermost aquifer (surficial materials and subcropping sandstones). The Phase II RFI/RIFS (Bedrock) Work Plan is scheduled for preparation in late 1990. As stated earlier, the Phase II RFI/RIFS will include a human health risk assessment and an EE.

A final remedial action may be proposed based on the Phase II investigation results, the human health risk assessment, and the EE. The baseline risk assessment is composed of both the human health risk assessment and the EE. The EE will address the potential environmental impacts associated with OU No. 2 under the "no-action" alternative (no remedial action taken). The EE will use the data collected in the RFI/RIFS process and supplement the data as necessary. The EE will also provide environmental information needed to evaluate potential ecological impacts of remedial alternatives and develop mitigation plans for these environmental risks, if any, by various alternative corrective measures or remedial actions considered in the Feasibility Study.

1.1.2 Site Background and Description

The 903 Pad and Mound Areas lie within the southeast portion of the 400-acre controlled area of the RFP, where all the production buildings are located. The East Trenches Area lies just to the west of the controlled area. The OU No. 2 areas are positioned on the east end of the Rocky Flats mesa in the watersheds of Woman Creek and South Walnut Creek. South Walnut Creek joins North Walnut Creek within the RFP buffer zone northeast of OU No. 2, and Walnut Creek flows are then diverted around Great Western Reservoir by the City of Broomfield's diversion ditch. Woman Creek drains into Standley Reservoir. However, much of the surface runoff from the RFP towards Woman Creek flows into the South Intercept Ditch between the plant proper and Woman Creek. Water collected by the South Intercept Ditch flows into Pond C-2 and is subsequently diverted to the Walnut Creek watershed.

Soils at OU No. 2 consist of Rocky Flats Alluvium which covers the mesa top. Soils on the sideslopes of the mesa are predominantly colluvium with minor terrace areas consisting of Verdos Alluvium and Slocum Alluvium. The creek valleys contain narrow areas of recent valley fill soil deposits and occasional small outcrops of the underlying Arapahoe Formation bedrock. The Arapahoe consists mainly of claystone with some bedded sandstone.

Unconfined ground water flow occurs in the surficial deposits and the shallow bedrock in directions generally parallel to the ground surface topography. Confined ground water flow occurs in the deeper bedrock sandstones. The shallow ground water discharges to the surface as seeps along the edge of the mesa where the contact between the base of the Rocky Flats Alluvium and the bedrock occurs and on down the hillslopes.

The vegetation on the east side of the RFP is characterized primarily by prairie grassland habitat. Limited areas of wetland and stream-bank vegetation occur along the creeks (DOE, 1980). Animal species are common mammals, birds, and reptiles of the High Plains Zone.

At OU No. 2, contamination has been observed in the surface soils, surface water flows, downhill seeps, and unconfined ground water. Surface soils in the area to the south and east are contaminated with plutonium, americium, and other radionuclides due to wind dispersal of particulates during clean-up of the 903 Drum Storage Site in the late 1960s (DOE, 1990a). Unconfined ground water is contaminated with volatile organics consisting primarily of carbon tetrachloride, tetrachloroethene, and trichloroethylene. Other constituents above background levels in the unconfined ground water include trace metals, major cations and anions, total dissolved solids, uranium 238, and possibly plutonium and americium (DOE, 1990a). Discharge of unconfined ground water occurs as evapotranspiration, as seeps at the edge of the mesa, and to surface water in the creeks. Site contaminants have been identified in many of the seeps (DOE, 1990a).

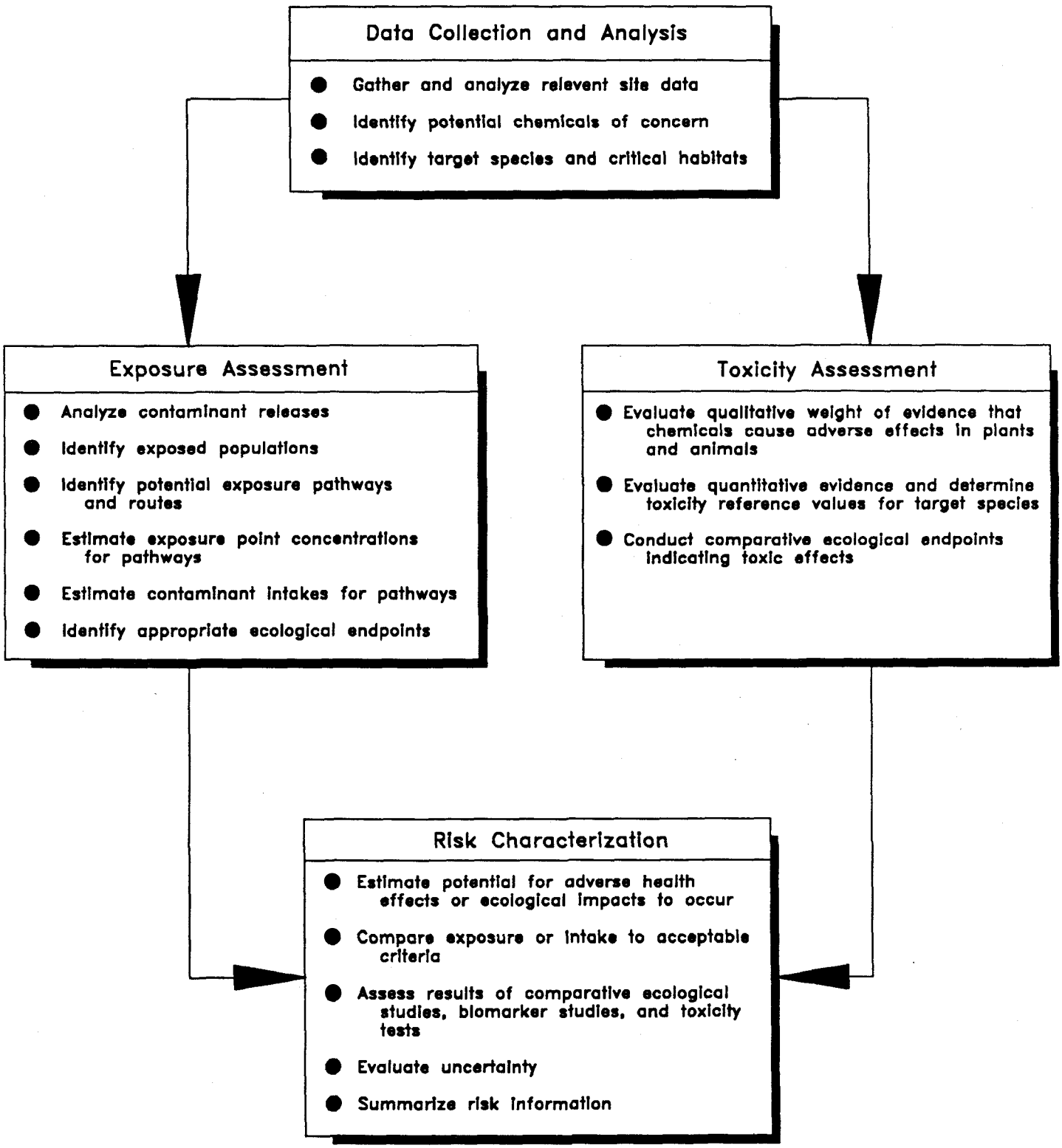
1.2 GENERAL APPROACH

An environmental evaluation (or ecological assessment) has much in common with the basic elements of a human health risk assessment. A risk assessment is, a process for analyzing the likelihood an adverse effect will occur, for determining the magnitude and intensity of that effect, and for measuring its spatial and temporal distribution. The principal steps in a CERCLA site risk assessment for determining risk to either human populations or the environment are basically the same; contaminant identification, exposure assessment, toxicity assessment, and risk characterization (Figure 2). In an ecological assessment, this is accomplished through evaluating site characteristics, determining the nature and extent of contamination, identifying the potential for exposure of plants and animals to contaminants, selecting ecological measurement "endpoints" to measure the ecological consequences of contaminant release, and assessing toxicity through dose-response techniques. These activities are combined with an evaluation of contaminants of concern to characterize the ecological risks.

This EEW undertakes a comprehensive approach to performing an ecological assessment including establishing objectives, developing an overall investigation methodology, implementing the workplan, and producing and documenting the results. As stated earlier, the EEW is based on guidance provided in the EPA EE Manual (EPA, 1989b) and other

Figure 2

Major Steps in Developing An Ecological Risk Assessment



guidance documents (see list of examples in Table 1 and the List of References at the end of Section 4.0).

TABLE 1

EXAMPLE U.S. ENVIRONMENTAL PROTECTION AGENCY AND U.S. DEPARTMENT OF ENERGY GUIDANCE DOCUMENTS AND REFERENCES FOR FIELD INVESTIGATIONS AND ENVIRONMENTAL EVALUATIONS

DOE, 1988, "Comprehensive Environmental Response, Compensation, and Liability Act Requirements," DOE Order 5400.YY, Draft September 1988.

DOE, 1988, "Radiological Effluent Monitoring and Environmental Surveillance," DOE Order 5400.XY, Draft September 1988.

DOE, 1990, "Radiation Protection of the Public and the Environment," DOE Order 5400.5.

EPA, 1989, "Risk Assessment Guidance for Superfund Volume II Environmental Evaluation Manual, Interim Final," Office of Emergency and Remedial Response, Washington, D.C., EPA/540/1-89/001.

EPA, 1989, "Ecological Assessment of Hazardous Waste Sites," Environmental Research Laboratory, Corvallis, Oregon, EPA 600/3-89/013.

EPA, 1989, "Exposure Factors Handbook."

EPA, 1988, "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final," Office of Emergency and Remedial Response, Washington, D.C., EPA/540/G-89/004.

EPA, 1988, "Superfund Exposure Assessment Manual," Office of Emergency and Remedial Response, Washington, D.C., EPA/540/1-88/001.

EPA, 1988, "Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites," Office of Emergency and Remedial Response, Washington, D.C., EPA/540/G-88/003.

EPA, 1988, "Technological Approaches to the Cleanup of Radiologically Contaminated Superfund Sites," Office of Research and Development, Washington, D.C., EPA/540/2-88/002.

Oak Ridge National Laboratory, 1986, "User's Manual for Ecological Risk Assessment," Environmental Sciences Division Publication No. 2679, ORNL-6251.

A comprehensive methodology for performing an EE is detailed in Section 2.0 of this EEW. The procedures recommended provide a means of determining and measuring ecological risks in a systematic, controlled, and step-by-step manner that can be used in subsequent efforts to reduce or manage the risk. While the EEW structures the methodology for conducting the environmental evaluation for OU No. 2, it does not attempt to define the unit either in terms of contamination extent or ecological characteristics; this will be accomplished during the actual implementation of the EEW.

This EEW also provides a framework for determining additional data needs and identifying the techniques (including sampling and analysis) to be employed in determining ecological risks. It provides a means for both quantitative and qualitative estimates of ecological effects such as reductions of biological growth or productivity, and changes in community composition.

By implementing the methodology described in Section 2.0 of the EEW, the subsequent EE will be able to determine the nature and extent of adverse effects on local ecosystems resulting from contaminants present at OU No. 2. Depending on the adequacy of the database, the ecological assessment has the potential for use of statistical, stochastic models to quantify the relationship of initial events (e.g., contaminant release) with probable ultimate effects (ecological consequences).

1.3 SCOPE OF THE ENVIRONMENTAL EVALUATION WORK PLAN

The principal focus of the EEW is on the basic methodology for performing an ecological assessment as described in EEW Section 2.0. This is because an understanding of the environmental assessment process is critical to implementing the tasks described in EEW Section 3.0. The ecological assessment process prescribed has been used at other sites and in other situations and is generally accepted by the scientific community.

The basic components in the EE methodology described in this EEW are:

1. Data evaluation and analysis, including nature and extent of contamination and site characteristics

2. Environmental analysis, including ecosystem characterization, field investigations, sampling and analysis, and exposure pathway analysis

3. Toxicity assessment which estimates exposure and dose, or measures ecological consequences using endpoints or bioaccumulation

4. Risk characterization based on dose-response analyses, toxicity and bioaccumulation studies, and ecological assessments.

The environmental evaluation, as described in the EEW, will draw conclusions about whether or not the objectives of the evaluation were achieved and identify the limitations of the analysis. It will also identify the limitations of the analysis (Figure 2).

EEW implementation is presented in Section 3.0 as separate tasks. The implementation plan will be used to schedule and estimate the cost of the entire EE process as well as to control the structuring and implementation of the various tasks. The ultimate scope of the EE is contingent on the availability of existing data and on the progress of the field investigations; it should be reviewed regularly as the evaluation process proceeds. Section 4.0 of the EEW addresses the various types of documentation that will result from the EE process, including the Environmental Evaluation Report (EER).

1.4 PURPOSE AND OBJECTIVES OF THE OU NO. 2 ENVIRONMENTAL EVALUATION

The overall purpose of an EE of the OU No. 2 area is to document a qualitative and, where possible, a quantitative assessment of actual or potential threats of damage to the environment including protected wildlife and vegetation species, habitats, or sensitive ecosystems. This purpose is consistent with the mandates of CERCLA/SARA and the IAG which states in Part 3 that one of its purposes is to ensure that "an appropriate response action is taken and completed as necessary to protect the public health, welfare, and environment." The purpose of the EE Work Plan is to establish a scientifically credible procedure to be followed and implemented during the performance of the EE for OU No. 2.

The EE will provide decision makers with information required to determine risk to the environment associated with contaminant migration from OU No. 2 as it exists and if nothing is done to remediate the site. It can also be used to determine whether or not contamination at OU No. 2 requires remedial action and to predict potential effects of those actions on the environment. In addition, the EE can suggest future strategies for monitoring the effectiveness of any remediation accomplished at or near the site.

The EE for OU No. 2 has multiple objectives. They are to determine:

- Ecological characteristics of OU No. 2 and its area of influence
- Kinds, forms, and quantities of contaminants of concern
- Means of potential or actual release of contaminants
- Habitats potentially affected and populations potentially exposed to contaminants
- Exposure pathways to potentially sensitive populations
- Actual or potential ecological effects and the overall nature of the risk.

2.0 ENVIRONMENTAL EVALUATION METHODOLOGY

This section identifies and discusses the principle components of the Environmental Evaluation for OU No. 2. They are presented in the sequence that would normally be followed in performing an ecological assessment. The major portion of the EE will be devoted to assessing ecological risks: environmental analysis (Subsection 2.2); toxicity assessment (Subsection 2.3); and risk characterization (Subsection 2.4).

2.1 DATA EVALUATION AND ANALYSIS

Site-specific (RFP) and operable unit specific (Operable Unit No. 2, 903 Pad, Mound, and East Trenches Areas) data and information collected during the Phase I RFI/RIFS program and prior studies by DOE and the RFP operating contractors will be reviewed and evaluated. Likewise, reports on the general area and scientific information on ecological processes related to this assessment (e.g., mobility of uranium in aquatic ecosystems) will be reviewed. These data and reports will be collected, analyzed, and complied as source documents. The principal objective of this effort is to determine what existing information can be used for the EE and define additional data requirements. The Phases I and II RFI/RIFS programs should provide the majority of the site-specific data needed on surface water, ground water, soils, and air quality. Previous environmental studies should provide the general ecological information. However, site-specific ecological data and estimates of contaminant and energy transfer in the OU No. 2 area will likely require additional investigations and additional data on sediments and sediment transport will be required.

In addition to the documents listed in Table 1, the following sources will be used to acquire information:

- Project files maintained by Rockwell International and EG&G
- Project reports and documents on file at the Front Range Community College Library and the Colorado Department of Health
- DOE documents and DOE orders
- The Phase I RFI/RIFS database

- The Rocky Flats EIS database
- Data from ongoing environmental monitoring and NPDES programs at the RFP
- Studies on radionuclide uptake, retention, and effects on plant and animal populations conducted by the University of Colorado and Colorado State University
- The scientific literature, including ecological and risk assessment reports at DOE facilities: Oak Ridge National Laboratory, Los Alamos National Laboratory, and the Savannah River Project
- The Surface Water Interim Measure/Interim Remedial Action Plan (IM/IRAP).

Several of the scientific reports that will be used are cited in various subsections of this EEW, including the Phase II RFI/RIFS Work Plan for Operable Unit No. 2 (DOE, 1990a), and the Final EIS on the Rocky Flats Plant (DOE, 1980). The references cited in this EEW are presented at the end of Section 4.0.

2.2 ENVIRONMENTAL ANALYSES

The biotic and abiotic components of the existing ecosystems will be described and analyzed to determine the impacts associated with the release of contaminants. This analytical process includes characterizing the principal ecosystems in the area (Subsection 2.2.1), determining which biological populations are at risk (Subsection 2.2.2), and identifying the exposure pathways to biological receptors (Subsection 2.2.3).

The environmental analysis will be coupled with the data evaluation and analysis process (Subsection 2.1) to determine specific data/information requirements for completing the EE. The field investigations, sampling, and analytical work to be undertaken to fill these data gaps are discussed in Subsection 2.2.4.

2.2.1 Ecosystem Characterization

The ecosystems at the Rocky Flats Plant site in the high plains region along the foothills include prairie grasslands on alluvial flats and fans interspersed with creek drainages and

riparian zones. Ponds and canals have been constructed within the drainages and offsite for runoff control and water retention purposes. These ecosystems will be inventoried and described to characterize the biotic resources within the RFP area.

In general, there are three levels of ecological organization to be characterized: populations, communities, and ecosystems. Each level has its own dimensions of extent, structure, and change. This EE will place more emphasis on assessing impacts at the population and community levels. For example, population dynamic parameters such as mortality and recruitment, and community endpoints such as species diversity and productivity, will be used to assess the impacts of contaminants. More detail on population and community endpoints is presented in Section 2.3.2. In determining the effects of the contaminants on biota, an understanding of the chemical, energy, and nutrient cycles in the ecosystems will be necessary to describe and analyze contaminant uptake and fate in the food chains.

The ecosystem characterization process includes inventorying and characterizing the terrestrial and aquatic biota in the area, describing the habitats that support the growth and existence of these biota, and defining the flow of nutrients and energy through the food webs of the ecosystem.

Flora and Fauna

Field investigations and existing reports will be used to determine which plants and animals make up the biological components of the ecosystems at the RFP. The primary objective will be to provide the best possible descriptions of populations in the area, commensurate with the accessibility of study areas and the time and personnel available. The amount, type, reliability, and currency of the data may vary according to species, time, and place. Inventories of the terrestrial plant, fish, and benthic macroinvertebrate communities will be very comprehensive, taking into account the scope of the field work. For other taxonomic groups, the species inventories will be based on existing reports, state and RFP records, and a list of species observed during field programs. Certain species and

populations will be selected for study based on criteria including, but not limited to, the following:

- Value as habitat quality indicators
- Local significance and public interest in the species/population
- Potential for the species/population to be impacted, and the ease of measuring the impact or stress
- Potential future conflict with RFP operations or remediation activities
- Critical nature of the habitat or sensitivity of the species/population (e.g., wetlands or threatened/endangered designations).

Each species or population selected for detailed study will be inventoried at the appropriate season to properly evaluate procedures and to maintain meaningful historical records. The sampling periods are discussed in the Field Sampling Plan in Appendix C. The goal will be to produce inventory information with the degree of reliability needed to effectively evaluate impacts at the environmental level.

Habitats

Available habitat is defined as the surface area capable of providing direct life support for an evaluation species (U.S. Fish and Wildlife Service, 1981b). The areal extent and potential for impacts resulting from contaminants at OU No. 2 on available habitats will be assessed.

Factors which may potentially affect habitats present at the Rocky Flats Plants would be addressed. These include:

- Direct or indirect exposure to site-related contaminants due to transport from the source
- Physical disruption of ecosystem processes due to contaminant interference with natural biochemical, physiological, and behavioral processes
- Physical disruption of the habitat due to the site's design or operation

- Physical or chemical disturbances or destruction due to cleanup or remedial activities

- Other stresses not directed related to the site, such as extreme weather conditions.

Food Webs

Energy and nutrients flow through ecosystems by means of complex interactions between organisms known as food chains and food webs. Food chains describe the transfer of energy and nutrients from one organism to another as one consumes or decomposes the other. Food chains selected for the EE will represent of the five major trophic levels:

- Primary producers
- Primary consumers (herbivores)
- Secondary consumers (omnivores)
- Tertiary consumers (carnivores)
- Decomposers.

Food webs are interconnecting food chains which realistically describe the complex system of pathways by which the flow of energy and nutrients take place in nature. A general discussion will be included to explain how the selected food chain(s) interrelate with the aquatic and terrestrial ecosystems found at the RFP and in the vicinity of OU No. 2.

2.2.2 Populations at Risk

The terrestrial and aquatic flora and fauna in the RFP area have been described by several researchers (Weber et al., 1974; Clark, 1977; Quick, 1964; Winsor, 1975) and summarized in the Final Environmental Impact Statement for the Rocky Flats Plant Site (DOE, 1980). Species lists are presented in the Appendix of this EIS. In addition, terrestrial and aquatic radioecological studies conducted by Colorado State University and DOE (Rockwell International, 1986; Paine, 1980; Johnson et al., 1974; Whicker, 1979; Little, 1976, and Hiatt, 1977) and annual monitoring programs at RFP have provided information on the plants and animals in the area and their relative distribution.

The above resources, discussions with RFP and Colorado Division of Wildlife (DOW) personnel, and on-site surveys will be used to determine the presence and distribution of

plants and animals with respect to OU No. 2. Distribution of plants and animals within, upgradient, and downgradient of the unit will be defined to fine-tune the ecological impact assessment approach and the Field Sampling Plan (FSP, Appendix C). The process of determining which populations are at risk involves sampling specific groups of organisms (e.g., benthic macroinvertebrates and prairie grasses), target species (e.g., fathead minnow and deer mice), and critical habitats (e.g., wetlands) as described in Appendix C.

Target species, target communities, and critical habitats will be selected for sampling using the following criteria:

- Susceptibility of the species, community, or habitat to the contaminants associated with OU No. 2
- Relationships between the target species, community, or habitat and the exposure pathways
- Degree of difficulty in accurately measuring the desired endpoint in that species or community
- Ability to define adequate reference and onsite test areas for the target species or community
- Amount of information in the scientific literature on the target species, community, or habitat; and the ecological significance of the species, community, or habitat
- Degree of difficulty and costs involved in conducting the necessary field sampling and laboratory analytical programs
- Potential for bioaccumulation or biomagnification of the contaminant of concern in the target species or community

Based on a preliminary review of the information available, some likely target species, communities, and critical habitats are presented in Table 2. The communities and habitats on this list may change if data collection or related research indicates that other species are also important.

Wetland habitats are known to be productive habitats that support a relatively diverse assemblage of plants and animals. Wetlands, therefore, will be considered a critical habitat

for this EE. Threatened and endangered species automatically fall within the "populations at risk" category and deserve special attention. However, prior studies indicate there may be no federally listed threatened or endangered species within the boundaries of the RFP (DOE, 1980, 1990b). The conclusions of these studies will be checked during the OU No. 2 EE. The project staff will also consult with the Colorado DOW to determine if there are any species of special concern from the State's perspective.

TABLE 2

POTENTIAL TARGET SPECIES AND HABITATS FOR ASSESSMENT OF ECOLOGICAL IMPACTS AT THE RFP OPERABLE UNIT No. 7

Community/Population	Species/Organism
Periphyton	Diatoms Green algae Blue-green algae
Benthic Macroinvertebrates	Mayflies Caddis flies Chironomids
Fish	Fathead minnow Bluegill
Herbivores	Deer mice Northern pocket gopher Microtines
Carnivores	Long-tailed weasel Red fox Coyote
Grasses	Western wheatgrass Blue grama
Shrubs/Forbs	Yucca Snowberry
Trees	Cottonwood
Wetlands	Willows Cattails Sedges

2.2.3 Pathway Analysis

An exposure pathway determines how a contaminant can move from its source to a receptor the environment. A complete exposure pathway has five components:

1. Contaminant source
2. Mechanism for contaminant release
3. Environmental transport medium
4. Exposure point (receptor location)
5. Route of exposure (mechanism for intake).

To qualify as a potential exposure pathway, all components of the pathway must be present. Numerous possible exposure pathways from the sources within OU No. 2 to plants and animals in the area will be assessed and several pathways will be selected for detailed analysis. The selected pathways will represent actual field conditions as related to rate of transfer as a function of time. Exposure pathways selected for analyses will include some or all of the target species. Pathways will be developed for the five transport media: air, soil, ground water, surface water, and sediments.

The logical exposure points at and near OU No. 2 will be identified. These will be based on modeling the release of contaminants from on-site sources and identifying biota likely to be present within the immediate location. The chemical transport and fate of contaminants will be evaluated using procedures in the EPA Superfund Exposure Assessment Manual (EPA, 1988b).

Many of the potential human exposure routes for constituents of concern at OU No. 2 also exist as possibilities for the endemic wildlife populations. These include inhalation of volatilized contaminants in air, inhalation of dust from contaminated soils, and dermal exposure to contaminated surface waters and soils. Since wildlife at or near OU No. 2 derive a major portion of their food supply from vegetation or prey species, migration of constituents through the food web with the subsequent possibility of biomagnification may provide a significant indirect route of exposure.

Quantitative analysis will be completed by using established EPA models for rate of transfer and fate of contaminants (EPA, 1988b) and for calculating specific intakes for each target species selected for quantitative evaluation. Standard equations for estimating human intakes (EPA, 1989b) may be used, where appropriate, to estimate intake rates for terrestrial vertebrates.

2.2.4 Field Investigations, Sampling, and Analysis

Because field investigation methods and sampling and analysis techniques are so critical to the scientific credibility of the EE, this section devotes a detailed discussion to these topics. Qualitative field surveys (Subsection 2.2.4.1), comparative ecology studies (Subsection 2.2.4.2), toxicity testing (Subsection 2.2.4.3), and bioaccumulation studies (Subection 2.2.4.4) are addressed. The Field Sampling Plan in Appendix C provides detailed information on sampling design, location, and intensity.

A preliminary assessment of the operational history of the RFP and OU No. 2, and a review of pertinent site characterization sections in available reports, indicates that completion of the EE requires:

1. Source characterization including presence, absence, and concentration gradients of contaminants
2. Exposure pathway characterization including contaminant release, media transport, and receptor exposure mechanisms
3. Determination of the presence, absence, and distribution of receptors
4. Assessment of toxicity or stress on the terrestrial and aquatic ecosystems present at the site.

The physical and chemical data required to address items 1 and 2 above, with some exceptions, will be available from the Phases I and II RFI/RIFS field investigations. Additional data on sediments adjacent to and downgradient of OU No. 2 will be collected to supplement planned investigations of potential impacts on aquatic ecosystems.

In order to address items 2, 3, and 4 above, additional data must be acquired on the flora and fauna in the area. The general biological components of the RFP area have been described by previous investigations (DOE, 1980; Rockwell International, 1986). However, more site specific data (i.e., specific to OU No. 2) and a more thorough understanding of the population and communities dynamics are necessary to complete the EE. For example, location-specific information on species diversity, biomass, cover class, and production within prairie grass communities at uncontaminated reference areas and at contaminated areas near OU No. 2 will be required to assess ecological risks.

The EE sampling methods will conform to the guidance manuals and sampling protocol references listed in Table 1 and the references cited at the end of Section 4.0. Evaluation techniques will include: qualitative field surveys; comparative ecological studies; toxicity assessment/testing; and bioaccumulation studies. Each of these techniques contributes a different type of information to the evaluation.

2.2.4.1 Qualitative Field Surveys

Field surveys will be conducted early in the process since the main objective is to get site-specific information on the occurrence of flora, fauna, and habitat types in order to fine tune sampling programs and complete a "reality check" on exposure pathways. Field surveys will also be used to select the best locations for reference (control) sampling areas. The field surveys will be conducted by qualified terrestrial and aquatic ecologists and will be largely qualitative. Some field instruments, such as pH and conductivity meters, will be used to assist in locating potential contaminant impacted areas, but most information will be acquired through visual observations. The field sampling plan (FSP) in Appendix C describes the qualitative survey plans in more detail.

During the qualitative surveys, details of field observations will be recorded in field logbooks. Field biologists will: record all observations of animal sightings and animal signs such as nests, burrows and scat; record locations of any sensitive habitats and wetlands; and note any evidence of stressed vegetation or visual evidence of contamination. They will also access the suitability of different habitat types to support aquatic and

terrestrial communities. In addition, field instruments will be used to search for evidence of contamination such as organic vapors in soils or obvious changes in pH and conductivity in surface water.

2.2.4.2 Comparative Ecology Studies

Ecological field surveys, involving comparisons of impacted and nonimpacted areas, are a definitive way of establishing that ecological impacts have occurred. However, care must be taken to account for differences in the physical/chemical aspects of the reference and test areas and the natural variations exhibited by biological populations. Ecological "endpoints" will be selected to assess contaminant impacts. To maintain a valid comparison, reference areas or sites will be selected that: (1) are in close proximity to the OU No. 2 area; (2) closely resemble the OU No. 2 area in terms of topography, soil composition, water chemistry, etc.; and (3) have no apparent exposure pathways from RFP or other sources of contamination.

Comparative ecological studies will be directed at three aquatic and five terrestrial communities or components: benthic macroinvertebrates, periphyton, fish, small mammals, grassland, vegetation, roots, invertebrates, and wetlands. These were selected because:

- There is extensive scientific literature available for interpreting results and making conclusions.
- The communities exist in impacted and nonimpacted areas of the RFP.
- Standard field techniques have been developed to measure the necessary community parameters.
- Surveys can be completed at reasonable costs.

Parameters such as relative abundance, species diversity, community organization, biomass, reproduction, and growth rates will be used to compare the communities at reference sites with communities in contaminated areas in or near the operable unit. Reference and contaminated sites will be carefully selected to minimize the influence of chemical and physical differences between the sites.

Periphyton, benthic macroinvertebrate, and fish communities will sampled at reference and test sites. Periphyton will be monitored using artificial substrates, macroinvertebrates will be sampled with Surber and Ekman samplers, and fish will be collected by electroshocking. Qualitative observations on all aquatic flora and fauna will supplement the quantitative sampling. Periphyton data will include colonization rates on the plexiglass substrates over a four week exposure period. Abundance, species diversity, biomass, and other parameters will be used to determine if communities within the test areas have been impacted in comparison to the reference area. Physical and chemical parameters such as substrate type, current velocity, and pH will be carefully documented to account for physical/chemical influence not related to contaminant releases.

Vegetation surveys of prairie grasslands and wetlands will be conducted by walking transects in reference and contaminated areas and noting general characteristics. Species abundance relative to cover vigor, and signs of stress will be used as assessment characteristics. Other surveys will be conducted for mammals, birds, and reptiles.

2.2.4.3 Toxicity Testing

The actual or potential toxicity of contaminants at stations within and near OU No. 2 will be assessed using three approaches: comparison of contaminant concentrations at exposure points to applicable or relevant and appropriate requirements (ARARs); comparison of existing concentrations to toxicological endpoints presented in scientific literature; and actual toxicity tests.

The initial step will be to compare average and maximum concentrations of contaminants of concern in air, soil, water, and sediments to established criteria. There are several well established criteria for aquatic ecosystems [e.g., water quality criteria for protection of aquatic life (EPA, 1986)] but relatively few criteria for air, soil, and terrestrial ecosystems. The amount or proportion by which concentrations exceed available criteria will be presented in tabular form, and the ecological significance will be interpreted.

In some cases, toxicity values are available in the literature for chemicals that have no criteria or standards. Toxicity values for contaminants of concern (for plants and animals known to occur at the RFP), when available, will be compared to average and maximum concentrations of contaminants in air, soil, sediments, and water to supplement the information on exceedances of criteria. Again, more data on aquatic organisms are expected to be available than on terrestrial organisms.

Comparison of on-site concentrations to criteria or toxicity values will not be sufficient to assess the potential impact of contaminants for which there are no criteria or toxicity values. Also, the comparison approach does not account for potential synergistic/ antagonistic effects in complex mixtures and may not adequately reflect the real bioavailability of the contaminant or the physico-chemical nature of the receiving waters. For this reason, a limited toxicity testing program will be conducted as an initial phase. If patterns of toxicity are encountered, a second phase of toxicity testing will be designed.

The initial toxicity testing program will be limited to aquatic organisms and will include standardized acute and chronic tests with fathead minnows and Ceriodaphnia (EPA; 1985a, 1985b, 1985c). Water samples for toxicity tests will be collected from two creek stations immediately downgradient of OU No. 2 (Stations SW-23 and SW-28), and from the downstream ponds on South Walnut Creek (Pond B-5) and Women Creek (Pond C-2) (see Figure C-1 in Appendix C). Standard EPA methods will be used to conduct the acute and chronic toxicity tests. The toxicity tests will be run during high-flow and low-flow conditions because the Phase I RFI studies have shown that there is considerable interaction between the surface and ground water systems at the RFP. Also, the influence of ground water may vary significantly under three different flow conditions.

The potential for a toxicity test involving soil and a terrestrial organism will be evaluated. If a relatively standard method is available using a species known to occur at the RFP toxicity tests will be proposed at reference and test areas. Toxicity tests developed for earthworms, crickets, and grasshoppers will be evaluated (EPA, 1989c).

2.2.4.4 Bioaccumulation Studies

Bioaccumulation analyses will be conducted for selected metal and radionuclide contaminants by sampling five communities used for the comparative ecology studies: periphyton, benthic macroinvertebrates, fish, small mammals, and prairie vegetation. The plants and animals will be collected during field sampling for the comparative ecological studies (Section 2.2.4.2). Because these organisms live in direct contact with the contaminated media (water, sediments, and soil), they are the most likely candidates to exhibit bioaccumulation. Samples will be collected from a limited number of stations that have exhibited prior contamination. If bioaccumulation is found to be occurring, the sampling program may be expanded.

The term "biomarkers" refers to the measurement of selected endpoints in individual organisms, typically physiological or biochemical responses, that serve as indicators of exposure to contaminants and/or sublethal stress. For example, exposure to some metals such as cadmium and copper induces the synthesis of certain low molecular weight metal-binding proteins in a variety of vertebrate and invertebrate species. Thus, the measurement of these metal-binding proteins provides a potential tool for assessing the affects of these metals. As used in this EE, bioaccumulation is also considered a biomarker because it is a measurement of an endpoint in individual organisms that indicates exposure.

There are many advantages of using biomarkers in ecological assessments including: their broad applicability to many toxonomic groups; the ability to link field surveys to laboratory tests to interpret the significance of field results; and the fact that some biomarkers are diagnostic of specific contaminants. However, there is currently a lack of accepted, standardized, and tested biomarkers for many of the contaminants found at hazardous waste sites. Also, the relationship between a measured biomarker response and population-level effects has not been defined in many cases.

For the above reasons, only bioaccumulation studies were included in the EE Field Sampling Plan (Appendix C). A specific biomarker approach may be developed later if it appears to be a realistic technique for assessing environmental impacts. For example,

biomonitoring studies at Oak Ridge, Tennessee, associated with the environmental restoration program at the Oak Ridge National Laboratory, have had some success using biomarkers (Loar, et al., 1988, 1989).

2.3 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to weigh the available evidence regarding the potential for particular contaminants to cause an adverse effect in exposed receptors (target species). It also provides, where possible, an estimate of the relationship between the extent of exposure to a contaminant and the increased likelihood and/or severity of adverse effects. Toxicity assessments for contaminants identified at OU No. 2 will be accomplished by incorporating evidence from more than one technique, where possible. Specifically, the assessment of toxicity for plants and animals may include evidence from: a dose-response assessment (a standard approach in human health risk assessments); comparative ecological surveys using endpoints of ecological significance (such as an increase in mortality rate); and bioaccumulation studies.

Many of the difficulties that arise during EE performance begin with the validity of techniques used to answer the seemingly easy question: Does a hazard exist? The use of the term "hazard" depends on the characteristics of the contaminant of concern and the circumstances of use. The Environmental Evaluation Report will clearly define this term and discuss techniques used in determining if a hazard(s) actually exists. An example toxicological profile is included in Appendix A.

2.3.1 Dose-Response Assessment (Extrapolation Models)

The most fundamental concept in toxicology is that a relationship exists between the dose of an agent and the response that is produced in a living organism. Dose-response assessment is the process of quantitatively evaluating the toxicity information and characterizing the relationship between the dose of the contaminant received and the incidence of adverse effects in the exposed populations. From this quantitative dose-response relationship, toxicity values (references doses, RFDs) are derived that can be used

to estimate the incidence or potential for adverse effects as a function of receptor exposure to a contaminant.

Because individuals and species accumulate contaminants differently in their tissues, environmental concentrations and uptake rates will not necessarily predict biotic concentrations. Pharmacokinetic distribution following uptake determines the concentration of a constituent that actually reaches the physiological site of action within an organism, and therefore, the likelihood of an adverse effect. For this reason, concentrations in environmental media and biotic tissues will be determined independently for some species. Based on these data, site-specific bioconcentration factors (BCFs) may be derived. If site-specific BCFs cannot be derived from the monitoring data, published and/or predicted BCFs will be utilized in the EE.

The final step in the dose-response assessment will be to evaluate the toxicity associated with contaminants. For several chemicals, toxicological data have been evaluated by the EPA or other agencies and RFDs for noncarcinogenic effects have been developed (EPA, 1987d). These RFDs are based on a survey of the current toxicological literature including both animal studies and human epidemiological studies. In cases where RFDs are not available, comparisons may be drawn between the contaminant-receptor relationship existing at OU No. 2 and appropriate laboratory studies that have developed other values expressing toxicity. Examples include LD_{50} and LC_{50} values and growth inhibition levels.

Cancer potency factors have been developed for many contaminants that are carcinogenic in humans (EPA, 1987d). Similar factors or extrapolations have been made to some animal species. Carcinogenic potency factors are expressed as the lifetime cancer risk per mg/kg body weight per day. Therefore, exposures need to be quantified or estimated over long time periods. Where possible, the toxic effects of some contaminants will be assessed using cancer potency factors. Generally, this will be limited to vertebrate animals. It may be most appropriate for small mammals (e.g., mice) that have been the subject of, or test organisms in, numerous laboratory experiments on carcinogens.

2.3.2 Comparative Ecological Studies

Ecological surveys will be used during the EE to study endpoints of ecological interest in selected target species or plant and animal communities (see Subsection 2.2.4.2). These receptors (the target species or selected community) are the components of the ecosystem that may or may not be adversely affected by the site specific contaminant being studied. The measurement endpoints are the particular type of impact a contaminant is expected to have on a given receptor.

Generally, endpoints of ecological interest may be divided into four levels: individual, population, community, and ecosystem. These levels may be further refined as:

- Individual endpoints
  - changes in respiration
  - changes in behavior
  - increased susceptibility to illness
  - decreased growth
  - death
- Population endpoints
  - decreased genotypic and phenotypic diversity
  - decreased fecundity
  - decreased growth rate
  - increased frequency of disease
  - increased mortality rate
- Community endpoints
  - decreased species diversity
  - decreased food web diversity
  - decreased productivity
- Ecosystem endpoints
  - decreased diversity of communities
  - altered nutrient cycling
  - decreased resiliencies

Because of the complexity of interactions within food chains (or in a food web), and the number and variety of receptors in an ecosystem, it is impossible to assess the potential

impacts to all receptors for all endpoints. Therefore, representative types of receptors and endpoints will be selected and used as indicators of potential effects on biological communities. Presently, there are no regulatory standards concerning individual assessment endpoints of biological interest for non-human aquatic or terrestrial species. There is, however, a general consensus defining adverse effects of measurement endpoints at the population level (EPA, 1989c) and, to a lesser extent, at the community level. Therefore, the EE will be limited to studying ecological endpoints in selected populations and communities. These may include some functional processes such as primary productivity in grassland, or fish biomass in ponds.

2.3.3 Bioaccumulation Studies

Measuring the accumulation of contaminants in living organisms provides direct evidence of exposure and uptake of the contaminant by the organisms, but does not necessarily equate to negative effects because many organisms tolerate some degree of bioaccumulation. Bioaccumulation, therefore, will be assessed using the field sampling results, scientific literature on the contaminant and receptor being studied, and other lines of evidence such as the comparative ecological studies. Where possible, bioconcentration factors [the ratio of the tissue concentration (fish) to the environmental media concentration (water)] will be determined and compared to bioconcentration factors reported in the literature. The potential for biomagnification of contaminants in higher trophic levels will also be investigated.

2.4 RISK CHARACTERIZATION

Information developed in the exposure and toxicity assessments (Subsections 2.2.2, 2.2.3, and 2.3) will be used to characterize the risk to plants and animals from contaminants released from OU No. 2. The information will be summarized and integrated into quantitative and qualitative expressions of risk. Comparisons will be made between projected intakes of chemicals (or other exposure estimates) and toxicity (as expressed by ARARs, toxicity test results, RFDs, or toxicity values from the literature) to characterize potential noncarcinogenic effects from exposure to chemical contaminants. To characterize potential carcinogenic effects from chemical contaminants, probabilities that an individual

organism will develop cancer over a lifetime of exposure will be estimated from projected intakes and chemical-specific dose-response information. The assessment of carcinogenic effects will not be developed to the extent found in human health risk assessments; carcinogenic effects on only a few species will be presented. Estimated dose equivalents and intake rates will be compared to ARARs and other guidance to characterize potential effects from radionuclide exposure.

The risk characterization will present estimates of risk for defined exposure scenarios plus summaries of the relevant biological information, identification of the assumptions used and their limitations, and a discussion of uncertainties. The risk characterization will address risks associated with organic and inorganic (metals) contaminants and radionuclides.

2.4.1 Organic Contaminants

The toxicity of organic contaminants is both general and specific. Effects observed in studies of experimental animals have been dependent on a variety of factors including chemical structure, exposure level, frequency and coexposure, and subject sensitivity. Studies to date at the RFP, especially those related to OU No. 2, indicate that volatile organic contaminants are much more prevalent than semi-volatile and base-neutral organics. There are relatively high concentrations of several volatile organics [e.g., trichloroethylene (TCE), tetrachloroethylene (PCE), carbon tetrachloride, vinyl chloride, and ethylbenzene] in various environmental media (soil, surface water, sediments, etc.). In contrast, there are apparently relatively few semi-volatile organics of concern.

Due to their high vapor pressure, volatile organics can be easily mobilized from one environmental compartment to another. They are very mobile in comparison to semi-volatiles and many inorganics; they can travel extensive distances in relatively short time periods. Kidney and liver enlargement are a common result of volatile organic toxicity because these chemicals induce mixed function oxidases. Prolonged exposure frequently results in damage to metabolic organs, and several volatile organics can induce carcinogenesis.

2.4.2 Inorganic (Metal) Contaminants

Toxicity of metals to aquatic organisms, plants, and soil-dwelling animals has been extensively researched. Scientific literature is available for assessing potential impacts. This is especially true for aquatic organisms.

There are a few general principles that contribute to understanding the pathophysiology of metal toxicity. Most metals affect multiple organ systems. The targets for toxicity are specific biochemical processes (enzymes) and/or membranes of cells and organelles. The toxic effect of the metal usually involves an interaction between the free metal ion and the toxicological target. There may be multiple reasons why a particular toxic effect occurs. For example, the metabolism of the toxic metal may be similar to a metabolically related essential element. Cells that are involved in the transport of metals, such as gastro-intestinal, liver, or renal tubular cells, are particularly susceptible to metal toxicity (Goyer, 1986).

The Phase I RFI/RIFS field investigations indicate that there are several metals in surface water, ground water, and soils at OU No. 2. Investigations are still in progress to determine which metals are present in concentrations exceeding expected natural background concentrations. However, it is likely that several metals which are toxic to plants and animals are contaminants associated with releases from OU No. 2. For example, cadmium, chromium, zinc, and vanadium have been observed in several media at concentrations that are likely above background.

The water quality data from the Phase I and II RFI field investigations will be compared to the water quality criteria for the protection of aquatic life (EPA, 1986). Additionally, the information in EPA's 1986 Water Quality Criteria report (EPA, 1986), the supporting ambient water quality criteria documents (e.g., zinc; EPA, 1987e), and the contaminant hazard reviews (e.g., chromium; see Eisler, 1986) will be used to evaluate the potential toxicity of metals to aquatic target species. The EPA ambient water quality criteria documents (e.g., EPA 1980, 1987e) also provide bioconcentration factors which can be compared, where available, to metal tissue residues in fish or macroinvertebrates. The

contaminant hazard reviews and other toxicological literature will also be used to evaluate the potential toxicity of metals to terrestrial plants and animals, again emphasizing the information relative to the target species selected for this EE.

Toxicity tests will be conducted to supplement the toxicity evaluation based on comparing on-site concentrations to criteria. The comparison-to-criteria approach does not consider synergistic/antagonistic effects that can occur when certain metals are present at the same time, or the influence that organic contaminants or other substances may have on metal toxicity (see Subsection 2.2.4.3).

2.4.3 Radionuclides

The radionuclides of concern associated with OU No. 2 are plutonium and uranium with smaller amounts of americium (DOE, 1990a). Other radionuclides that are potential contaminants in water are cesium-137, strontium-89, 90 and tritium (DOE, 1990a). However, the Phase I RFI/RI data for these three radionuclides are inadequate to assess contamination.

The dispersion of radionuclides from the RFP into air, soil, sediment, water, and biota have been studied and summarized in a report on the radioecology and airborne pathway at the facility (Rockwell International, 1986). Also, the ecological effects of plutonium in the environment at the RFP were assessed on biota by measuring biological parameters and by pathological examination (Whicker, 1979; Paine, 1980). The conclusions of these studies indicate that plutonium is relatively immobile in the environment, and that no differences in biological attributes could be related to plutonium levels found in environmental media at the RFP.

Specific ARARs for radionuclide contamination in environmental media are generally calculated for human health protection. Very few studies have been conducted to relate the effects of radionuclides on non-human receptors. Most plant populations are less sensitive than animal populations to radionuclides or their radiation. In most cases, the plants in the grasslands at the RFP are short-lived and turnover is rapid. Most species of

wildlife are also short-lived and, therefore, not sensitive to radiation effects. The exceptions are a few long-lived predatory bird and mammal species which may be sensitive to radiation effects. Soil invertebrates or anthropods may be sampled and used as indicators of plutonium uptake and possible bioaccumulation in the terrestrial environment. However, these populations have rapid turnover rates with respect to numbers, nutrients, and energy. They may not be good indicators of effects in many cases.

The aquatic ecosystems at the RFP may exhibit bioaccumulation of radionuclides. They will be sampled and evaluated during this EE. Previous sampling of aquatic communities in ponds and lakes near the RFP has revealed some bioaccumulation in seston (the mass of various living and nonliving substances in the water column) but, apparently, no transfer of plutonium within the food chain (DOE, 1990a).

Literature searches will be conducted to locate toxicity studies on plant and animal populations involving plutonium and americium. Also, studies investigating the carcinogenicity and other toxic effects of plutonium, but involving high doses in controlled laboratory conditions, will be evaluated to see if any of the results might be applicable to conditions at OU No. 2. In addition, limited toxicity tests may be conducted on target organisms to assist in determining what concentrations might be toxic.

2.4.4 Risk Analysis

The risk posed by contaminants released from OU No. 2, assuming "no action," will be assessed using one or more techniques. Six different methods of analyzing risks to the environment from contaminants present at OU No. 2 are discussed in this Subsection:

1. Comparing exposure point concentrations to published criteria or doses with known adverse effects

2. Comparing toxicity test data on laboratory organisms (e.g., fathead minnows) to actual populations in the landfill environment

3. Comparing populations of plants or animals existing in contaminated areas to the same populations in uncontaminated or "reference" areas

4. Using a quantitative dose-response assessment for a limited number of species

5. Using or bioaccumulation methods

6. Applying quantitative fault/event tree analysis.

The first method, referred to as the quotient method, involves comparing the concentrations of a contaminant at known exposure points to published criteria or regulatory standards (ARARs), or to a dose known to cause adverse or toxic effects (for example an LC_{50}). As discussed in previous sections, the risk from chemical or radiological contaminants to populations in nature, based on toxicity tests or epidemiological data, are not available in many cases. Therefore, the quotient method can be used, employing criteria that have been established from the toxicological literature.

A second risk analysis method involves comparing data from laboratory toxicity tests on standard species to native species, such as laboratory mice to deer mice in the grassland near OU No. 2. Appropriate correction factors must be applied to incorporate variability among species, life stages, and so forth, and to account for differences between conditions in the laboratory and in the natural environmental. This method will yield an indication of what concentration of a contaminant will be a safe level, below which no adverse effects are expected to occur. A logical refinement of this method would be to conduct toxicity tests on native species using water or soil from the OU No. 2 area, simulating environmental conditions as much as practical.

A third method is based on comparing on-site populations in known or expected contaminated areas to similar populations at reference (upgradient uncontaminated) areas. Population parameters (e.g., growth rates, reproduction rates, and mortality rates) or community parameters (e.g., species diversity, standing crop, and productivity) are used to assess the differences between the populations in impacted and non-impacted areas. At the concentrations of contaminants expected in the RFP ecosystems, this method may not be sensitive enough to unequivocally determine consequences.

In the fourth method, if the ratio of the daily intake to an acceptable intake exceeds 1.0 (unity) for the defined exposure scenario, there is an indication that the exposed species may be subject to an adverse impact and that further investigation should be undertaken. If the ratio is below unity, it is generally assumed that no adverse impact will occur. This method is comparable to the human health risk assessment approach.

In the fifth method, exposed populations are examined to determine if tissue concentrations are greater than environmental media concentrations. The tissue to media ratio is referred to as the bioconcentration factor (BCF). Tissue concentrations can also be estimated from published BCF sources if the on-site media concentration is known.

A sixth method for analyzing risk that will be considered for possible use at OU No. 2 is the use of fault/event tree analysis. This process examines the release scenarios, pathway analyses, and possible consequences to the ecosystems in a step-wise sequence. It uses logic diagrams in phased scenarios to which probabilities can be assigned. This is a quantitative probability method in which uncertainties can also be quantified.

Other methods that have been used for ecological assessment, such as ecosystem modeling are not appropriate for use at OU No. 2. This method involves the use of computer simulation and requires extensive field verification of the assumptions in the modeling.

2.4.5 Uncertainty Analysis

All risk estimates are dependent on numerous assumptions and the many uncertainties that are inherent in the EE process. In any evaluation of the level of risk associated with a site, it is necessary to address the level of confidence or the uncertainty associated with the estimated risk.

Uncertainties are associated with both toxicity information (e.g., hazard identification and dose-response assessment) and exposure assessment information. Consequently, factors that may significantly increase the uncertainty of the EE results will be identified and addressed in a qualitative and, where possible, a quantitative manner.

Three qualitatively distinct sources of uncertainty endemic to any EE are: inherent variability, parameter uncertainty, and model error. It is essential to distinguish between these uncertainty parameters since they differ with respect to feasibility of quantification and degree of possible reduction through research or environmental monitoring (Barnthouse et al., 1986).

Inherent Variability

Constraints on the precision with which variable properties of the ecosystem can be measured will limit the precision with which it will be possible to predict the ecological effects of stress. The concentration of a constituent in a medium varies unpredictably in fate and transport (space and time) because of essentially unpredictable variation in meteorological parameters such as precipitation and wind direction. The spatiotemporal distributions and sensitivities to stress of the target species in nature are similarly variable. This variability can be quantified for many characteristics of the physical environment that influence the constituent's environmental fate (Barnthouse et al., 1986). For the OU No. 2 EE, actual analytical data will be used as the estimates of constituent soil and water concentrations. Variable biological aspects of the ecosystem will be more difficult to quantify.

Parameter Uncertainty

Errors in parameter estimates may introduce additional uncertainties. Parameter values from the scientific literature may be estimated from structure-activity relationships or from taxonomic correlations that are not corrected for site-specific parameters. In addition, direct laboratory measurements may be subject to error. Unlike inherent variability, however, uncertainties due to parameter error may be reduced by increasing the precision of measurements or by replacing extrapolated parameter estimates with direct measurements where possible.

Model Errors

Model errors will constitute the least tractable source of uncertainty in the EE. Major sources of model error are: (1) using a small variable to represent a large number of

complex phenomena; (2) choosing incorrect functional forms for interactions among variables; and (3) setting inappropriate boundaries or limits on the model universe (Barnthouse et al., 1986). Although these errors cannot be completely eliminated from the EE, one of the EE objectives will be to reduce them as much as possible.

3.0 ENVIRONMENTAL EVALUATION WORK PLAN IMPLEMENTATION

This section describes ten different tasks under which the EE will be organized, staffed, managed, and performed. This task structure will be employed as the principal vehicle for scheduling and budgeting the entire EE process. Program flexibility will be required as the nature and scope of any particular task may need to be modified depending on the results of the review of existing data, field investigations, and the sampling and analysis program. The tasks are subdivided into those dealing with project organization and those involving actual performance of the EE.

3.1 PROJECT ORGANIZATION AND MANAGEMENT

The tasks described in this section pertain to project organization, quality assurance and quality control, health and safety, documentation, and control of schedules and costs. Tasks pertaining to EE performance are described in Subsection 3.2.

3.1.1 Task 1: Project Organization and Management

The EE will be a multidisciplinary undertaking staffed by specialists from several different scientific and technical disciplines. The project will be managed by a Task Manager who will have primary responsibility for the following functions:

- Coordination of all ten EE tasks
- Selection and assignment of personnel
- Cost estimating, scheduling, and schedule/cost control
- Tracking of documentation and preparation of the EE report (EER)
- Liaison with EG&G and submittal of progress reports and other documentation
- Coordination with whatever contractors are performing the OU No. 2 RFI/RIFS.

The EE staff will include, but not necessarily be limited to, specialists in the following disciplines:

- Surface water and ground water hydrology
- Soils science/geology
- Terrestrial ecology
- Aquatic ecology
- Environmental toxicology
- Climatology
- Computer modeling
- Health and safety
- Quality assurance
- Costs/schedule control.

Representatives of each of the technical and scientific disciplines will work together as a team to characterize the OU No. 2 site and the surrounding area that could possibly be affected by OU No. 2 contaminants. The exact geographic scope of the investigation cannot be determined until existing literature has been reviewed and some field work has been undertaken. The scientific and technical team will identify the geographic scope, the location of sources of contamination on or near the site, the types and distribution of ecological habitats, and the nature of possible air, water, sediment, and soil pathways. The details of these investigations are described in the methodology discussion in Section 2.0.

The EE for OU No. 2 cannot be conducted in a vacuum. Throughout the EE process, it will be important to coordinate efforts with those who are simultaneously performing the RFI/RIFS and the health risk assessment. It will also be necessary to coordinate with those responsible for EEs or other types of investigations at OUs in close proximity to OU No. 2. Presumably, these coordination efforts will be expedited by EG&G personnel.

3.1.2 Task 2: Quality Assurance and Quality Control (QA/QC) Program

The EE will be implemented under the Quality Assurance Program Plan (QAPP) and the project-specific Quality Assurance Task Plan (QATP). The QATP is consistent with the draft QAPP prepared for the Environmental Restoration Program at the RFP (Rockwell International, 1989c). It is likely that this has been updated by an EG&G contractor. The QATP will describe the QA/QC policy and protocols necessary to achieve the required data quality objectives (DQOs).

The QAPP and QATP program will address such items as:

- Project organization
- Authorities and responsibilities
- QA objectives
- Sampling and analysis procedures
- Custody of samples
- Analytical procedures
- Data validation reporting
- Internal quality control
- Data assessment procedures
- Quality assurance reports
- Auditing.

3.1.3 Task 3: Health and Safety Plan

A Health and Safety Plan, needed to meet the minimum requirements identified in the Rocky Flats Plant Environmental Restoration Program Site Health and Safety Plan Workbook (EG&G, 1990), will be developed for the EE prior to the commencement of any field investigations or field sampling. The Workbook addresses the following health and safety requirements:

- Safety and Health Assessment (chemical, radiological, biological, and physical hazards)
- Training
- Personal Protective Equipment (PPE)
- Site Monitoring
- Decontamination
- Emergency Response
- Confined Space Entry
- Spill Containment

Because OU No. 2 contains 18 solid waste management units (SWMUs) [or individual hazardous substance sites (IHSSs)], personnel involved in the actual field work and sampling will be required to have 40 hours of Occupational Safety and Health

Administration (OSHA) training. They will be instructed in the use of personal protective equipment (PPE) appropriate for the level of hazardous substances expected to be found. The Health and Safety Plan will also address decontamination procedures for personnel and equipment.

In addition, all personnel assigned to field activities at OU No. 2 will receive two hours of health physics training. This training will address the types of radionuclides expected at the unit and the potential effects of human exposure. Appropriate precautions and protective measures for those potentially exposed to radiological hazards will be incorporated into the Health and Safety Plan.

3.1.4 Task 4: Project Documentation

The EE will produce multiple types of documents and documentation requirements: EEW modifications; progress reports; minutes of meetings with EG&G; field data; photographs; existing reports and other data; records of telephone conferences; scientific literature; sampling and analytical data; and the draft and final EE reports. To the extent practical, all EE documentation will be retained in the same location for easy access by members of the project team.

3.1.5 Task 5: Scheduling, Costing, and Schedule/Cost Control

Personal computer-based software systems will be used to prepare schedules and assess cost/schedule performance. Basic information for the cost/schedule tracking software will be provided by downloading from the IT Job Tracking System (JTS). The JTS is an IBM System/38 which provides weekly current-period and job-to-date reports for labor, materials, equipment, outside services, and analytical costs.

The scheduling software to be employed for the EE is a Super Project Planner (SPP). The SPP is a personal computer-based planning system which integrates schedule, resource allocation, and budget. The Task Manager will establish a schedule allocating resource personnel and time requirements to each of the EE tasks. The planned costs for the EE will be established and a budget calculated for each activity and each task.

A performance measurement system which measures the percent complete and the actual costs of each activity against the budgeted costs will be utilized throughout the EE. Variances in actual costs and schedule when compared to the projected baseline will then be tracked and evaluated.

3.2 ENVIRONMENTAL EVALUATION

The tasks described in this section address data evaluation and analysis, field investigations including field sampling and analysis, the ecological risk assessment, and preparation of the EE report. These tasks may need to be modified depending on the nature and extent of the existing database.

3.2.1 Task 6: Review of Existing Information

The depth and breadth of existing data and site information pertaining to OU No. 2 and its immediate vicinity is not currently known. Several reports, including the Phase I RFI/RIFS and the Phase II RFI/RIFS Work Plan, are available for OU No. 2. There are also monthly and annual RFP Environmental Monitoring Reports as well as some rather generic information on plant and animal species and habitats including wetlands.

As the list of references included in this EEW indicates, there are a number of sources of useful information in the scientific literature and in reports prepared by Colorado State agencies and universities. The collection and review of the existing database on wetlands and floodplains, threatened and endangered species, meteorology, geology, soils, hydrogeology, hydrology, geomorphology, and other topics will in itself be a significant task. It will guide how each of the subsequent tasks are to be conducted.

3.2.2 Task 7: Data Evaluation and Analysis

As discussed in EEW Subsection 2.1, site-specific information and the scientific literature will be reviewed and analyzed to provide a comprehensive data source for the EE. The data evaluation and analysis task will review the existing database to determine, among other things, the following:

- Identification and concentration of contaminants of concern (organics, metals, and radionuclides)
- Site-specific characteristics (climatology, surface water, ground water, soils, geology, hydrology, geochemistry, and terrestrial and aquatic ecosystems)
- Adequacy of data and additional data needs.

The nature, extent, and scientific credibility of the existing database will, in great part, dictate the parameters for the field investigations in Task 8.

3.2.3 Task 8: Field Investigations (Including Field Sampling)

The approach to field investigations, including field sampling and analysis, is described in detail in Subsection 2.2.4 and Appendix C. Field investigations will be adequate to determine: (1) contaminant source characterization; (2) exposure pathway characterization; (3) presence, absence, and distribution of biological receptors, and (4) assessment of toxicity or stress on terrestrial and aquatic ecosystems. While data required to address items (1) and (2) is assumed to be available from the Phase I and II RFI/RIFS investigations, some additional data (e.g., information on sediments) will need to be collected in the field. Also, additional data will need to be developed for flora and fauna in order to develop a thorough understanding of population dynamics. Specifically, information will be developed in the field on species diversity, biomass, sensitive habitats, and food webs. All these data will be needed to assess at risk.

Field investigations will include each of the items addressed in Section 2.2.4:

- Qualitative field surveys (including sensitive habitats such as wetlands or riparian vegetation)
- Comparative ecology studies (involving comparisons of impacted and nonimpacted reference sites)
- Sampling of periphyton, benthic macroinvertebrates, fish, small mammals, wetlands, and grassland vegetation
- Toxicity testing.

Once Tasks 6 and 7 have been completed and the additional data needs specified, the field sampling plan will be reviewed and modified if necessary. The plan describes sampling techniques, field instrumentation, and data management. It will also be integrated with the Health and Safety Plan. The following factors were considered and specified in the field sampling plan where they are applicable:

- Number and qualifications of participating personnel
- Optimal dates for investigation
- Weather conditions
- Survey units
- Observation points
- Lists of equipment and supplies
- Sample management
- Field data forms
- Summary data forms
- Sampling requirements
- Statistical analysis requirements.

3.2.4 Task 9: Ecological Risk Assessment

The assessment of risk to terrestrial and aquatic organisms and ecosystems will be accomplished through the environmental analysis, toxicity assessment, and risk characterization described in EEW Subsections 2.2, 2.3, and 2.4. The environmental analysis will characterize ecosystems, populations at risk, and potential contaminant pathways. The ecosystem characterization will include biotic resource inventories (wildlife, vegetation, and aquatic organisms). While population information exists for species present at the RFP, the amount, type, currency, and reliability of the database will vary by species from place to place. Habitats will be characterized considering: direct or indirect exposure to contaminant transport; physical disruption of ecosystem processes; physical disruption of habitat due to site design or operation; and other stresses not related to the site or its constituents (e.g., extreme weather conditions). Food webs are organized according to the five major trophic levels:

- Primary producers
- Primary consumers (herbivores)
- Secondary consumers (omnivores)
- Tertiary consumers (carnivores)
- Decomposers.

The first two trophic levels will be the main thrust of this assessment. The last three trophic levels are composed of wide-ranging species or, in the case of decomposers of specialized organisms difficult to measure, and will not be handled directly. These trophic levels could be a RFP site-wide study objective.

Populations at risk will be determined by analyzing the distribution of plants and animals within, upgradient, and downgradient of OU No. 2. Potential ecological impacts will be assessed using several lines of evidence which are described in detail in EEW Subsection 2.2. Target or indicator species will be evaluated to determine site specific constituent impacts.

The risk characterization will provide an evaluation and a summary of all the information that has been collected and present this information in an understandable manner. The risk characterization will also include selection of criteria for organic chemicals, metals, and radionuclides. It will include both a qualitative and a quantitative analysis of risks together with their probability of occurrence (see EEW Subsection 2.4.4). Further, the risk analysis will include an analysis of uncertainties that are intrinsic to the EE process (EEW Subsection 2.4.5).

This task will also summarize the results of the ecological risk assessment to determine if the objectives were accomplished and if there are uncertainties that have not been resolved.

3.2.5 Task 10: Environmental Evaluation Report

The preparation of the EER will necessitate the accomplishment of three steps or subtasks:

- Submittal of a draft EER
- Review and comment by EG&G
- Response to EG&G comments
- Incorporation of responses to comments and submittal of a final EER.

The format and content of the EER is addressed in EEW Section 4.0. The major steps in developing the EER are illustrated in Figure 2. A suggested EER outline is included in Appendix B.

4.0 FORMAT AND CONTENT OF THE ENVIRONMENTAL EVALUATION REPORT

The results of the EE will be presented in a clear, concise manner. The conclusions will be organized around the risks posed by contaminants from OU No. 2 to specific plant and animal species. Final conclusions will be based on lines of evidence from several assessment techniques. The conclusions section will include a discussion of EE objectives to determine if they were accomplished. Also, uncertainties associated with the EE will be presented, along with an evaluation of how these uncertainties influence the conclusions. The EE will determine whether OU No. 2 presents an unacceptable environmental risk unless remedial actions are undertaken.

The EER will have three basic uses. It will be used to:

- Determine the nature and severity of the environmental risk resulting from existing contamination conditions at OU No. 2 without remedial action (the "no action" alternative)
- Determine the need for remedial action and provide information needed to evaluate potential environmental impacts of remediation alternatives
- Prepare appropriate environmental documentation needed to comply with the National Environmental Policy Act (NEPA).

The introductory sections to the EER will define the objectives and scope of the EE investigation and generally describe the physical and biological characteristics of the site. Information from prior studies, such as the OU No. 2 RFI/RIFS field investigations, will be used to: identify the contaminants of concern; assess the sources and fate of transport mechanisms for these contaminants; and describe the logical pathways and receptor species or communities.

The characterization of risks in the EER (see EEW Subsection 2.4) will be based on several lines of scientific evidence. For example, one line of evidence will be based on comparisons of contaminant concentrations to organic chemical, metal, or radionuclide criteria in addition to toxicity data from the literature. Another line of evidence will

compare biological communities at on-site stations to reference off-site stations. Thus, there will be subsections of the report that do not exactly align with those shown in Figure 2.

Since the assessment of risk to biological receptors is largely based on the weight of the evidence supporting particular conclusions, a summary section will be included in the EER. This section will present the various lines of evidence supporting (or failing to support) each basic conclusion and discuss the associated uncertainties. The factors that limit or prevent development of definitive conclusions will be described and the degree of confidence in the data used will be presented.

The EER will be structured and written to facilitate its use by a diverse audience: technical specialists, scientists, administrators, and the general "lay" public. Portions involving technical detail, such as explanations of methodologies or fate and transport models, will be presented in appendices. An Executive Summary will be prepared to briefly present the basic information contained in the ecosystem characterization, exposure, toxicity, and risk assessment portions of the report and describe how this information supports the risk characterization conclusions. A glossary will be included to define technical terms along with a list of acronyms. A complete list of references, including the scientific literature cited, will also be included. Appendix B contains a suggested OU No. 2 EER outline.

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APPENDIX A
EXAMPLE TOXICOLOGICAL PROFILE
1,1-DICHLOROETHANE

1,1-DICHLOROETHANE

A.1.0 INTRODUCTION

The chlorinated ethanes are produced in large quantities and used for production of tetraethyl lead and vinyl chloride, as industrial solvents, and as intermediates in the production of other organochlorine compounds. All of the chlorinated ethanes studied have been found to be mildly toxic, with toxicity increasing with the degree of chlorination. Density and melting point also increase with halogen substitution. Conversely, both water solubility and vapor pressure descrease with halogen substitution.

1,1-dichloroethane has the molecular formula $C_2Cl_2H_4$ and a molecular weight of 98.96. Also known as ethylidenechloride or ethylidenedichloride, pure 1,1-dichloroethane has a vapor pressure of 182 mm Hg, a water solubility of 5,500 mg/l (Archer, 1979) and a log K_{ow} of 1.79 (Valvani et al., 1981). Based on these data, this compound would be expected to partition into the water column in aquatic ecosystems, rather than adsorb to suspended particulates. It has an estimate half-life in water of one to five days and a half-life in air of one and one-half months (Callahan et al., 1979); no half-life value for 1,1-dichloroethane in soil could be located in the available literature. However, evaporation is expected to be the predominant loss mechanism from the soil surface. The half-life for soil evaporation should be longer than its evaporation half-life from water. In subsurface soil, the loss of 1,1-dichloroethane through biodegradation is expected to be insignificant (Wilson et al., 1983). Therefore, 1,1-dichloroethane may persist in soil and is expected to be removed primarily through leaching into ground water.

Halogenated hydrocarbons have been identified in 80 domestic water supplies by Symons et al. (1975). 1,1-dichloroethane was among the compounds identified in finished water of several metropolitan areas (Coleman et al., 1976; Kopfler et al., 1976).

A.1.1 ENVIRONMENTAL TOXICITY

Few animal studies have been conducted with 1,1-dichloroethane. In a study conducted by Larson et al., three dogs were intubated with 200 mg/kg body weight (bw) for six days/week for eight weeks in order to observe the effects on the adrenal gland. All three animals survived and none had significant histopathology of the adrenals. Other parameters of toxicity were not reported. Rats given 1,1-dichloroethane in a corn oil carrier via gavage exhibited depressed body weights at dosages greater than 1,000 mg/kg bw (NCI, 1978). Males appeared susceptible to lower doses than females. However, these studies were considered too limited in their assessment of toxicity criteria to be useful in risk assessment.

Of several species tested, cats appeared to be the most sensitive to inhaled 1,1-dichloroethane. Blood urea nitrogen levels were immediately elevated during post-exposure and peaked at approximately three times the normal level. Histopathological examination of the cats revealed renal tubular dilation and degeneration, indicating kidney damage (Hofmann et al., 1971). Based on data from this study and another by Torkelson and Rowe (1981), a no observed effect level (NOEL) of 500 ppm (2,025 mg/m^3) can be suggested for subchronic exposure in rats, cats, guinea pigs, rabbits, and dogs.

The only study of chronic oral toxicity to 1,1-dichloroethane was reported in the NCI carcinogenicity assay (NCI, 1978), in which 50 male and 50 female rats and mice were intubated with the compound in a corn oil carrier. Treatments were administered for five days/week for three weeks, followed by one dose-free week and three additional treatment weeks over the 78-week treatment period. All groups of male and female rats exhibited a hunched appearance, abdominal urine stains, labored breathing, wheezing, and nasal discharge. Although there were no definitive signs of 1,1-dichloroethane toxicity in physical appearance or behavior of the mice, survival of both males and females was adversely affected.

In Schwetz et al. (1974), female rats were exposed to 0, 3,800, or 6,000 ppm 1,1-dichloroethane via inhalation for seven hours/day on days 5 to 15 of gestation. The highest

dose resulted in an increased incidence of delayed ossification of sternebrae in the newborn rats.

A.1.2 HUMAN TOXICITY

At one time, 1,1-dichloroethane was used as an anesthetic, with an anesthetic pressure of 0.026 atmospheres, -105,000 mg/m^3 (Miller et al., 1965). The ability of the compound to induce cardiac arrhythmias caused discontinuation of its use as an anesthetic (Browning, 1965). It is probable that human exposure to sufficiently high levels of 1,1-dichloroethane would cause central nervous system (CNS) depression and respiratory tract and skin irritation, as is the case in exposure to many other chlorinated aliphatics. Although the EPA (1980, 1983) stated that no information was available on unusual sensitivity of any groups to any of the chlorinated ethanes, it was suggested that individuals with liver insufficiency or exposure to other hepatotoxins may be at increased risk. Presumably, individuals with impaired renal function may also be unusually sensitive to exposure to 1,1-dichloroethane. In general, there is a paucity of information regarding the impact of this compound to human health.

A.1.3 CARCINOGENICITY

In the 1978 NCI carcinogenicity assay, female rats demonstrated a significant dose-response relationship in the incidence of hemangiosarcoma. However, male rats showed no significant change in neoplastic incidence that was related to the 1,1-dichloroethane compound. Mammary adenosarcomas were also considered significant in the females, using the Cochran-Armitage test for linear trend in proportions. However, significance was not demonstrated using the Fisher Exact test. In female mice, the Cochran-Armitage test showed a positive dose-response relationship in the incidence of benign endometrial stromal polyps that was coincident with results of the Fisher Exact test. NCI concluded that this evidence suggested the possible carcinogenic potential of 1,1-dichloroethane but deemed it inconclusive.

Weisburger (1977) reviewed NCI's bioassays of several halogenated aliphatics and noted that 1,1-dichloroethane and tetrachloroethylene both induced hepatocellular carcinoma in

mice. Although the incidence of this type of tumor was not considered significant, the similarity in lesions produced by other members of this chemical class raised a concern that the marginal results may well be biologically important. Nevertheless, neither IARC nor the Carcinogen Assessment Group of the EPA has classified 1,1-dichlorochloroethane as to carcinogenicity, placing it into Group D -- Not Classified chemical.

APPENDIX B

SUGGESTED OUTLINE FOR THE RFP OPERABLE UNIT No. 2

(PRESENT LANDFILL)

ENVIRONMENTAL EVALUATION REPORT

APPENDIX B

SUGGESTED OUTLINE FOR THE RFP OPERABLE UNIT No. 2 (PRESENT LANDFILL) ENVIRONMENTAL EVALUATION REPORT

EXECUTIVE SUMMARY

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- General problem at site
- Site-specific objectives
- Scope

1.2 SITE BACKGROUND

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  - Hydrogeology
  - Ecology
  - Meteorology
- Site Map
- General History
  - Ownership
  - Operations
  - Known or potential contaminants
  - Land use
- Significant site reference points
- Geographic location relative to off-site areas of interest
- General sampling locations and media

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- Assignment and rationale
- Overview of study design

1.4 ORGANIZATION OF ENVIRONMENTAL EVALUATION REPORT

2.0 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

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- Surveys and field investigation
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- Data from site investigations
  - Summary of methods and quality control
  - Data analysis
- Uncertainties, limitations, gaps in quality of data

2.3 SUMMARY OF CHEMICALS OF POTENTIAL CONCERN

- Criteria
- Receptors

3.0 EXPOSURE ASSESSMENT

3.1 CHARACTERIZATION OF EXPOSURE SETTING

- Physical setting
  - Climate
  - Vegetation
  - Soil type
  - Surface hydrology
  - Ground water hydrology
  - Ecological habitats (e.g., prairie, pond, riparian vegetation)
- Potentially exposed populations
  - Nature and extent of contamination
  - Assessment of sensitive environments
  - Habitats potentially affected by site contamination
  - Populations potentially exposed to contaminants

3.2 IDENTIFICATION OF EXPOSURE PATHWAYS

- Sources and receiving media
- Fate and transport in release media
  - Physical, chemical, and biological processes
  - Decomposition rates and products
  - Bioaccumulation potential
- Exposure points and exposure routes

3.3 POTENTIAL FOR EXPOSURE

- Seasonal or climatic variations
- Site-specific geophysical, physical, or chemical conditions

3.4 QUANTIFICATION OF EXPOSURE

- Exposure concentrations
- Route of intake

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- Exposure concentration versus toxicity data from literature
- Identification of Uncertainties
- Summary of Exposure Assessment

4.0 ECOLOGICAL EVALUATION

4.1 AQUATIC ENVIRONMENTS

- Periphyton
  - Algal types, species diversity, standing crop (biomass), productivity
- Benthic Macroinvertebrates
  - Abundance, species diversity, tolerant/intolerant species, biomass

4.2 TERRESTRIAL ENVIRONMENTS

- Grassland Flora
  - Herbaceous and shrub species, cover class, biomass, primary production, dominant species
- Grassland Fauna
  - Species diversity, standing crop, variety of vertebrates and invertebrates, evidence of stress
- Wetland Flora
  - Abundance, species diversity, biomass, production, visible evidence of stress

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4.4 EVALUATION OF POTENTIALLY AFFECTED POPULATIONS

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6.1 SUMMARY OF RISKS

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- Based on comparative ecology assessment
- Based on toxicity assessment

6.2 OVERALL SCENARIO OF RISK ASSESSMENT

7.0 SUMMARY

7.1 CHEMICALS OF POTENTIAL CONCERN

7.2 EXPOSURE ASSESSMENT

APPENDIX C
FIELD SAMPLING PLAN

C.1.0 INTRODUCTION

The Field Sampling Plan (FSP) for the OU No. 2 Environmental Evaluation describes the program for sampling flora and fauna within and near the operable unit in order to assess the ecological consequences of releases of contaminants. The FSP will be thoroughly integrated with the RFI/RIFS field sampling program and ongoing sampling by the Rocky Flats Environmental Monitoring and Analysis Program (EMAP). It is these programs that provide data on contaminant concentrations and extent of contaminant migration in surface water, ground water sediments, soils, and air.

The OU No. 2 field sampling procedures have been developed following protocols recommended by the EPA (1987a, 1988a, 1989b, 1989d), the U.S. Fish and Wildlife Service (1981a, 1981b), and those currently being used at the RFP (DOE, 1990a). The FSP will follow the Quality Assurance Program Plan and Data Quality Objectives (DQO) developed for the RFI/RIFS program as well as the standard operating procedures used by the EMAP for current field monitoring operations (Rockwell International, 1989a, 1989c). Sampling procedures will also conform to existing and new health and safety plans, sample and waste management protocols, and EE-specific data quality objectives (Rockwell International, 1989b; EPA, 1987c; DOE, 1990a).

The field sampling program will consist of a qualitative field survey conducted in the Spring, followed by quantitative field sampling in late Spring and early Summer and in late Summer and early Fall. Although the initial field survey will be primarily quantitative, limited quantitative samples and water/soil quality measurements will be taken (Section C.3.0). Likewise, during the two quantitative sampling efforts, the sampling teams will record qualitative observations of flora and fauna to assist in interpretation of the field data collected during the program. The initial qualitative survey will be scheduled to coincide with the start of the growing season of prairie vegetation.

As recommended in the EPA Environmental Evaluation Manual (EPA, 1989b), the ecological field sampling at OU No. 2 will be carefully integrated with the RFI/RIFS sampling for OU No. 2 in order to coordinate the water, sediment, and soil sampling efforts with the ecological sampling. It will be especially important to schedule the surface water and sediment sampling to coincide with the periphyton and benthic macroinvertebrate sampling. Where possible, vegetation sampling will be located in the same areas and scheduled to coincide with soil sampling. In addition to planning sampling events during the same time frame, the ecological evaluation staff will review RFI/RIFS sampling procedures and analytical protocols for water, sediment, soil, and air samples so that the data necessary to develop and model exposure pathways will be available from the RFI/RIFS program.

The ecological field sampling at OU No. 2 will be integrated with the ecological field sampling at OU No. 1 so that the data produced at these two adjacent operable units are compatible. It is assumed that periphyton, benthic macroinvertebrate, and fish data from three or more stations sampled as part of the OU No. 1 field effort will be made available to the OU No. 2 field program. The OU No. 2 field sampling team will work closely with EG&G to integrate this sampling plan and the ecological assessment effort with appropriate physical, chemical, or ecological sampling conducted by EMAD.

The Spring qualitative field survey will be a reconnaissance assessment involving systematic documentation of specific visual observations and collection of qualitative and quantitative field samples that may be processed in the field. Since this survey involves limited data generation and analysis of samples and water/soil quality data in the field, its effectiveness depends to a large extent on the experience of the professional biologists performing the survey. These biologists must have impact assessment experience as well as experience in field ecology surveys in the types of habitats present at OU No. 2.

2.0 SAMPLING OBJECTIVES

The RFI/RIFS sampling program will provide data on the concentrations of contaminants in environmental media (i.e., water, air, soil, sediments), the plume characteristics, the source characterization, and the extent of contaminant migration within and near OU No. 2. This source characterization will allow the EE project team to compare contaminant concentrations at exposure points to ARARs and other environmental criteria and assess the ecological significance of the contaminants. Contaminant concentrations will also be compared to the toxicological literature to determine if on-site concentrations could potentially be toxic to the aquatic and terrestrial species present at OU No. 2, if applicable data is available on the contaminants of concern. Contaminant concentration data will also be used to develop quantitative dose-response assessments of toxicity, providing that adequate information is available on exposure in order to compare actual intake rates with acceptable intake rates. However, some data may be missing from that required to fully develop the dose-response scenario.

The ecological field sampling program has two overall objectives:

1. Characterize biological resources in order to conduct the ecological impact assessment by supplementing the RFI/RI data base.

2. Acquire the data necessary to measure ecological effects of contaminants that cannot be assessed by the dose-response approach (including comparisons with ARARs and toxicity data).

In general, the ecological field sampling program will provide data necessary to compare aquatic and terrestrial communities at impacted and reference areas, measure toxicity directly, or measure the accumulation of contaminants in plant and animal tissue. As stated in the introduction, the field sampling program is divided into two components: qualitative surveys followed by quantitative field sampling. The objectives of the qualitative surveys are as follows:

- Acquire additional site-specific data on plants, animals, and habitat types at OU No. 2 to assist in identifying potential exposure pathways

- Acquire data needed to characterize the major ecosystem components in the OU No. 2

- Determine the presence, absence, and distribution of plant and animal receptors within and near OU No. 2
- Identify threatened or endangered species, critical habitats, and sensitive species that are of concern at the RFP and OU No. 2
- Acquire information needed to "fine tune" the quantitative sampling plans presented in this FSP
- Select reference (unimpacted) stations for terrestrial and aquatic sampling purposes
- Observe and document obvious indications of contamination and, if possible, impacts on biota or habitats
- Fill gaps identified during review of existing data.

The objectives of the quantitative ecological field sampling program are as follows:

- Acquire additional information needed to assess seasonal changes in habitat types and document the presence and distribution of flora and fauna
- Measure ecosystems for composition, productivity, standing crop or biomass
- Collect quantitative data to estimate intake rates, exposure times, and food chain relationships
- Measure indicators of toxicity (ecological endpoints) and assess the differences between endpoints in populations and communities in impacted and reference areas
- Measure toxicity directly by standard EPA biomonitoring methods
- Measure accumulation of selected inorganics and radionuclides in plant and animal tissue
- Fill data gaps identified during the literature review and the qualitative field surveys.

C.3.0 QUALITATIVE FIELD SURVEYS

The purpose of the qualitative field survey is to develop a thorough familiarization with site characteristics in order to guide the quantitative field surveys. All site features of OU No. 2 will be covered in the reconnaissance field surveys including topography, drainages, aquatic habitats, vegetation, animals, wetlands, and other biota and habitats.

This FSP was based in part on information produced by the Phase II RI/RFI and, more specifically, on a recent site visit to OU No. 2. During this site visit, a portion of the source area (MOUND East Trenches) was traversed on foot so that observations could be made on general conditions. Windshield and walking surveys were made in the drainages of South Walnut Creek and Woman Creek, and on the flat grassland and slopes to the east of the IHSSs. The relationship of the source areas to surface water springs and seeps, and associated wetlands, along with ponds and streams below or adjacent to the source areas, was noted.

The initial qualitative field survey will be conducted in the Spring of 1991, coinciding with the start of the growing season of grassland vegetation. The survey will be designed to meet the objectives stated in Section C.2. The survey will be designed to describe the aquatic and terrestrial ecosystems at and in the vicinity of OU No. 2, identify the species and habitats present, further define the conceptual model of contaminant transport by biotic and abiotic mechanisms, and select reference areas for comparative ecological studies. The initial survey will also be used to confirm the sampling locations, frequencies, and protocol for the quantitative sampling effort to be conducted later in the Spring and Summer.

The initial qualitative survey will include locating and evaluating all sampling sites for quantitative sampling, including several potential reference areas. The survey will include: documenting visual observations; collecting some quantitative vegetation, benthic macroinvertebrate, and fish samples; and testing aquatic and terrestrial habitats with field instruments to detect indications of contamination (e.g., the presence of volatile organics in soil or seep areas or specific conductivity and pH in aquatic systems). All observations will be recorded in field logbooks. Field instruments will be checked and calibrated daily.

The qualitative field surveys will be planned in advance to provide the following information:

- Physical description of all sampling sites
- Documentation of similarities and differences between the reference areas and on-site sampling locations
- Identification and initial inventory of plant and animal species
- Results needed from field instrument readings
- Vegetation/habitat map and descriptions of principal habitats
- Description and location of critical or sensitive habitats; list of threatened or endangered species observed
- Description of the principal exposure pathways and conceptual model of principal food chain relationships
- Qualitative description of benthic macroinvertebrate and fish communities at stations along Woman Creek and South Walnut Creek
- Qualitative descriptions of wetland and prairie grassland communities, including identification of dominant and subdominant species
- Descriptions and locations of obvious signs of impact on terrestrial vegetation or aquatic communities
- Abundance of key terrestrial and aquatic receptors.

Subsections C.3.1, C.3.2, and C.3.3 describe the qualitative field surveys of aquatic ecosystems, terrestrial ecosystems, and reference areas.

C.3.1 AQUATIC ECOSYSTEMS

The initial qualitative field survey of aquatic habitats will along Woman Creek and South Walnut Creek as well as the South Interceptor Ditch from the apparent headwaters down to the surface water sampling stations below Pond C-2 and Pond B-5. Since these two ponds are currently operated as zero discharge structures, apparently no aquatic habitat exists along the lower reaches of South Walnut Creek and Woman Creek between these ponds and the downgradient limits of OU No. 2. An ecologically similar section of Rock Creek, in the northern buffer zone, will be

included in the walkover survey to identify potential reference areas for quantitative sampling (Section C.4.0) and conduct a comparative assessment of Rock Creek and Woman Creek.

Also, the qualitative field survey will include observations and qualitative sampling at all seep areas identified in the OU No. 2 area during the Phase I RFI/RIFS investigations. The survey will result in descriptions of the physical and biological characteristics of sampling stations planned for the quantitative sampling program, potential reference areas, and ground water seeps within OU No. 2.

The physical characteristics of stream sections (including the South Interceptor Ditch) and ponds will be documented in the field logbook and on field survey maps. Descriptive parameters such as stream width and depth, pool/riffle ratios, water velocity, bottom substrate, bank vegetation, proportion of undercut banks, fish cover, and channel morphology will be recorded. Frequent measurements of water temperature, specific conductivity, and pH will be taken along the creeks and at seeps to document potential contaminant and/or ground water inflow.

The biological characteristics of stream sections, ponds, and seeps will be described using three techniques:

1. Qualitative observations of filamentous algae, slimes, aquatic macrophytes, and vertebrate and invertebrate animals;

2. Qualitative sampling of fish with short seines and dip nets; and

3. Sampling of benthic macroinvertebrates utilizing the Rapid Bioassessment Protocols (RBP I) developed by EPA (1989d) for cost-effective assessments of lotic systems.

Fish collected by seines and dip nets will be identified, measured (total length), and released. Abnormalities such as fin rot, lesions, and external parasites will be recorded.

The RBP I reconnaissance assessment technique for benthic macroinvertebrate communities will be used to discriminate obviously impacted and non-impacted areas from potentially affected areas requiring further investigation. The RBP I method focuses on qualitative sampling of benthos, supplemented by a preliminary examination of other aquatic biota such as periphyton,

macrophytes, fish, and slimes. At least half of the aquatic sampling stations selected for quantitative sampling will be assessed using the RBP I technique. Standard field data sheets will be used to record the relative abundance of macroinvertebrate orders (Families for Megaloptera and Diptera); occurrence of periphyton, algae, aquatic macrophytes (plants); abundance of fish by species; and water quality measurements.

The results of the qualitative field survey will be summarized in a Technical Memorandum. The major components of this Technical Memorandum are listed in the introduction to Subsection C.3.1. The occurrence of potential contamination along Woman and South Walnut Creeks and the South Interceptor Ditch will be defined based on results of field water quality measurements, observations of obvious contaminant impacts such as stressed vegetation or absence of aquatic organisms, and biological indicators. Some examples of biological indicators include changes in species diversity, absence of pollution sensitive taxa or dominance of pollution-tolerant taxa, abundance of filamentous algae, or large differences in reference and impacted areas. The Technical Memorandum will also include recommendations for revisions to the quantitative sampling program if warranted, and the rational for those changes. The qualitative survey could result in the addition, deletion, or revision of some of the quantitative sampling locations described in Section C.4.0.

C.3.2 TERRESTRIAL ECOSYSTEMS

The qualitative field surveys for the terrestrial ecosystems will follow a similar protocol and timing as for the aquatic ecosystems. The entire area of OU No. 2 will be walked to identify terrestrial communities and general ecosystem components. Information developed will be verified from other sampling programs on biota in the area of OU No. 2. Observations will be made on species present and voucher specimens will be collected. Information will be collected on general distribution of plant and animal species, boundaries of plant community types and habitats, and the physical and biological condition of the vegetation and habitats. Wetlands around springs and seeps and along drainages will be located and delineated for later quantitative sampling. All observations will be recorded in field logbooks and voucher specimens will be given a unique identification.

The physical limits of the proposed sampling locations will be determined. A reconnaissance will be conducted of the vegetation, small and large mammals, predators, birds and signs of animals (tracks, scat, skeletons, burrows, etc.). Obvious signs of impacts or effects of contaminants will be looked for at sampling locations close to the source areas. Observations on recent biological activities that may impede or increase the movement of soil- or water-borne contaminates will be noted. In particular, a visual survey will be made for ants and fossorial animals such as gopher which bring large amounts of subsurface soil to the surface where it is distributed by wind. Observations will also be made for badgers and foxes which excavate dens or dig in search of prey.

The selection of species or ecosystem components to be collected for qualitative sampling or tissue collection will be verified. Based on information from the Phase I and II RFI/RIFS, the wetland plant communities developed around springs and seeps downgradient of the source areas may be sensitive indicators of contaminant migration via the ground water pathway. Wetland plant communities are known to filter and accumulate contaminants such as heavy metals. These wetland areas will be examined for evidence of contaminant accumulations. A second component that may accumulate contaminants are roots of grassland species growing in contaminated soils, either through root uptake or adherence of particles. A preliminary assessment of rooting depths and densities will be conducted at selected locations by shallow hand-dug trenches and gridding of root depths on exposed soil faces.

Qualitative surveys for mammals, birds, reptiles will be conducted by systematically walking the area on preselected routes at appropriate times. Bird surveys will be conducted at dawn and dusk. Records will be kept of species and other features observed such as numbers, condition, habitat, and activities. Other evidence of animals or birds including burrows, scat, and nests will be recorded. Checklists will be prepared for the qualitative surveys of animal and plant species to record survey information.

The results of the qualitative field surveys for terrestrial ecosystems will be included in the Technical Memorandum discussed in Section C.3.2. The specific conditions of the grassland and wetland ecosystems will be discussed as they relate to exposure pathways. Obvious indicators

of stress related to contamination including pathological conditions such as necrosis, chlorosis, and stunting of organisms will be described. Other indicators are the diversity and abundance of species in impacted areas. Revisions in the quantitative sampling plan may result from the qualitative survey.

C.3.3 REFERENCE AREAS

The use of reference areas is a definitive means of comparing impacted and nonimpacted areas as discussed in Section 2.2.4.2 of the EEW. Reference areas for each ecosystem and component will be selected during the qualitative survey at locations not impacted by contaminants. These areas will generally be upwind of and upgradient from OU No. 2 to avoid contamination. They will be similar in topography, soils, water chemistry, and ecosystems present. A quantitative field survey will be conducted at the reference areas using the same procedures and protocol developed for OU No. 2. The number of reference areas chosen and their size will reflect the major vegetations and aquatic types determined in OU No. 2 during the qualitative surveys. As a practical matter, generally one reference area for each major ecosystem type will be chosen. Reference areas will be chosen to separate the effects of contaminants from those of physical disturbance. This will be accomplished by keeping the physical characteristics of the reference areas as similar as possible to those on the operable unit, and controlling access and sampling disturbance.

C.4.0 QUANTITATIVE FIELD SAMPLING

Quantitative sampling of aquatic and terrestrial ecosystems at OU No. 2 will be conducted primarily to characterize the ecosystems and measure the ecological consequences of contaminants released. The quantitative sampling program will include characterizing the biota at selected sampling stations, conducting comparative ecological studies, measuring contaminant bioaccumulation, and measuring potential toxicity of discharges from downgradient ponds on Woman and South Walnut creeks. The quantitative sampling will supplement qualitative survey information used for characterizing the ecosystems, identifying major plant and animal receptors, and developing exposure pathways. Qualitative observations will continue to be recorded when field investigations are conducting quantitative sampling.

Field sampling operations for conducting comparative ecological studies, measuring bioaccumulation in selected species, and measuring potential toxicity of water discharges are described in the following FSP subsections and in Subsections 2.2.4 and 3.2.3 of the EEW. The field procedures will be carefully integrated with similar ecological assessment field studies at OU No. 1, with the National Pollutant Discharge Elimination System (NPDES) program at the RFP which assesses water quality of plant discharges (including Ponds C-2 and B-5), and with routine monitoring and special sampling events conducted by the EMAP group. Selection of sampling locations will be coordinated with the RFI/RIFS Work Plan, specifically for surface water, sediment and surficial soil sampling locations.

C.4.1 AQUATIC ECOSYSTEMS

The FSP for aquatic communities will include sampling periphyton, benthic macroinvertebrates, and fish at selected stations on Woman Creek, South Walnut Creek, and the South Interceptor Ditch (SID). Ground water seeps and one or more reference areas will also be sampled. Reference areas will be selected for comparative ecological studies of creek stations. However, since the ponds on Woman Creek and South Walnut Creek are controlled and operated as zero discharge facilities (and are not intended for wildlife or recreational use), the FSP will not establish reference areas for the pond habitat.

The stations selected for quantitative sampling are listed in Table C.1 and shown on Figure C-1. The locations may be modified following the qualitative field survey in the Spring of 1991. As indicated in Table C.1, a few stations are designated for both the OU No. 1 and OU No. 2 field programs. In these cases, the stations should be sampled by only one field crew, with the results of the field sampling being submitted to the project staffs for both operable units.

C.4.1.1 Periphyton

The periphyton communities at reference and test sites will be monitored using standardized artificial substrate (plexiglass) samplers suspended in the water column. Samplers will be anchored at each station and exposed for four weeks. Water quality data will be collected weekly during the exposure period and the physical and biological characteristics of the sampling station will be documented. At the end of the colonization period, the periphyton will be scraped off the plexiglass slides and analyzed for species or genera, species diversity, biomass, and chlorophyll content.

Location/Frequency

Periphyton samples will be collected at 12 locations on the South Interceptor Ditch, Woman Creek, and South Walnut Creek and at one or more reference areas (Table C.1 and Figure C-1). No samples will be collected at the ground water seep areas within OU No. 2, or at the most downstream stations on Woman and South Walnut Creeks, because there is not enough water flow or depth for the samplers. Instead, qualitative samples will be taken from natural substrates at these locations.

Periphyton samplers will be set for two four-week periods, essentially corresponding with high (late Spring-early Summer) and low (late Summer-early Fall) flow conditions. Since there is substantial interaction between the surface and ground water systems at the RFP, the influence of contaminant releases from the source areas may vary considerably under high and low flow conditions.

Table C-1
Sampling Stations for Aquatic Ecology--Operable Unit No. 2

Drainage	Station No.	Aquatic Sampling			Description
South Interceptor Ditch	SW-A	Periphyton	Benthos		Upgradient of OU No. 1 and OU No. 2
	SW-70[a]	Periphyton	Benthos	Fish	Between OU No. 1 and OU No. 2
	SW-54	Periphyton	Benthos	Fish	Downgradient of OU No. 2
Woman Creek Watershed	SW-B	Periphyton	Benthos		Upgradient of OU No. 1 and OU No. 2
	SW=32A[b]	Periphyton	Benthos	Fish	Between OU No. 1 and OU No. 2
	SW-C1	Periphyton	Benthos	Fish	Pond on Woman Creek
	SW-28	Periphyton	Benthos	Fish	Downgradient of OU No. 2
	SW-C2[a]	Periphyton	Benthos	Fish	Pond collecting SID water
	SW-26[c]		Benthos		Most Downgradient Station; Pond C-2 Discharge
South Walnut Creek Watershed	SW-23	Periphyton	Benthos		Downgradient of Mound Area and Building 991
	SW-B4	Periphyton	Benthos	Fish	Pond on South Walnut Creek
	SW-24	Periphyton	Benthos		Downgradient of Pond B-4
	SW-B5	Periphyton	Benthos	Fish	Lowest Pond on South Walnut Creek
	SW-25[c]		Benthos		Downgradient of Pond B-5
Groundwater Seeps	SW-55[c]		Benthos		Downgradient of 903 Pad (Source Area)
	SW-53		Benthos		Downgradient of 903 Pad and East Trenches
	SW-65		Benthos		Downgradient (south) of Trenches and Spray Field
	SW-103		Benthos		Downgradient (north) of Trenches and Spray Field
Reference	SW-C	Periphyton	Benthos	Fish	Upper end of Woman Creek or Rock Creek

[a]Stations SW-70, SW-32, and Pond C-2 will be sampled for Operable Unit No. 1 and Operable Unit No. 2.
[b]Recommend aquatic samples be taken at SW-32A (alternate) rather than SW-32 so sampling station is closer to the dividing line between OU No. 1 and OU No. 2.
[c]Stations SW-26 on Woman Creek (below Pond C-2), SW-25 on South Walnut Creek (below Pond B-5), and groundwater seeps (SW-53, 55, 65, and 103) apparently do not have enough water flow for artificial substrate (periphyton) samplers.

Field Methods

Two artificial substrate samplers holding six plexiglass slides will be placed at each sampling location at the beginning of the exposure period. The sampler consists of an anchor and float assembly with the plexiglass slide holder suspended in the water column about 30 cm below the water surface. Co-located samplers will be located at each station and placed in similar habitats within a 30-meter stream section. At two stations, the second sampler will be used for duplicate samples. At the remaining stations the second sampler will be used if additional biomass is needed for bioaccumulation (tissue analysis) or if the primary sampler is lost.

Flow conditions and other physical and biological characteristics of the sampling station will be documented in the field log when the sampler is set and picked up. Field instruments will be used to measure water quality parameters (temperature, pH, conductivity) at the beginning and end of the four-week exposure period (28 days $\pm$ 1 day) and at weekly intervals during the exposure period. Flow conditions will also be estimated weekly. Dissolved oxygen concentrations will be measured at the discretion of the field biologist, especially at pond stations. Other field measurements may be taken where visual evidence suggests contamination. Qualitative observations regarding the occurrence of periphyton, filamentous algae, fish and amphibians, and slimes on natural substrates will be recorded in the field log.

Sample Preparation/Analysis

Periphyton material will be collected from different slides for identification and enumeration, biomass determinations, and chlorophyll-a/phaeophytin-a concentrations. The slides will be selected randomly.

For identification and enumeration, all periphyton will be scraped from both sides of a slide and transferred to a sample vial with distilled water. The sample will be diluted, preserved, and allowed to settle in a sedimentation cylinder for approximately 12 hours. The sample will then be resuspended in 200-1000 ml of water, depending on the volume of the sample, and the organisms will be identified to the genus level and counted at about 320X magnification.

For biomass determinations, the periphyton growth from one or two slides will be scraped into a preweighed crucible. The sample will be dried at 105°C for 12 hours (or until a constant weight is obtained), weighed, and then ashed in a muffle furnace at 600°C for one hour and weighed again. The difference between the two weights is the ash-free dry weight (organic weight) of the sample.

Periphyton from both sides of a slide will be scraped into a container and placed in a 90 percent acetone solution for chlorophyll/phaeophytin analyses. The sample extract (about 20 to 50 ml) will be homogenized, steeped for 12 hours, and centrifuged. The optical density of the extract at 750 and 630 nanometers (nm) will be determined by spectrophotometer and the concentration of chlorophyll-a will be recorded. The concentration of phaeophytin-a will be determined from optical density readings at 633 nm before and after acidification.

For tissue analysis (bioaccumulation), six composite samples will be collected, placed in glass vials, and stored on ice. The composite samples will be collected from the following locations:

Sample 1	SW-70 and SW-54 (SID
Sample 2	SW-32A and SW-28 (Woman Creek)
Sample 3	Ponds C-1 and C-2 (Woman Creek)
Sample 4	SW-23 and SW-24 (South Walnut Creek)
Sample 5	Ponds B-4 and B-5 (South Walnut Creek)
Sample 6	SW-C (Reference Area)

Periphyton will be scraped from 6 to 9 slides at each sample station and transferred to glass vials using distilled water. Samples will be stored on ice in the field, then composited in the field laboratory. Periphyton samples will be shipped fresh (on ice) to the analytical lab within 48 hours of collection, or frozen and shipped at a later time.

Ecological Endpoints

Periphyton samples will be analyzed for cell counts, genera, species diversity, biomass, and chlorophyll-a and phaeophytin-a concentrations. The standing crop (biomass) at the end of the four-week exposure period will be an estimate of colonization rate. Chlorophyll/phaeophytin concentrations will provide an estimate of productivity. Proportions of pollution-sensitive and pollution-tolerant genera will be reported.

Equipment

The field equipment needed for periphyton sampling includes the following:

- Field data sheets for recording site descriptions, water quality data, flow conditions, etc.
- Periphyton samplers with anchors and floats
- Boots and waders
- Boat and oars, anchor and life preservers
- Sample containers, labels, preservatives
- Water quality field instruments
- Cooler and ice
- Decontamination equipment
- Instrument calibration standards.

C.4.1.2 Benthic Macroinvertebrates

Benthic macroinvertebrates are the most common fauna used in ecological assessments of contaminant releases or pollution discharges. They are defined as the aquatic invertebrates that are large enough to be seen without magnification and capable of being retained by a U.S. Standard No. 30 sieve (0.595 mm openings). Benthic macroinvertebrates will be collected from all sampling stations. In cases where the habitat does not allow quantitative sampling, qualitative samples will be collected with dip nets and by grab samples of substrate and coarse particulate organic matter (CPOM, e.g., leaves, twigs, and plant debris).

Location/Frequency

Benthic macroinvertebrates samples will be collected at all 19 stations used for quantitative aquatic sampling (Table C.1 and Figure C-1). Macroinvertebrates will be sampled quantitatively in the late Spring-early Summer and late Summer-early Fall. The intent is to sample under low flow and high flow conditions. The creek and pond sample stations will be defined as a 50-meter

segment of the creek or a 50-meter section of the pond shoreline. In the ponds, samples will be taken at depths less than two meters deep, generally in the inlet or discharge areas of the pond.

Field Methods

Two types of benthic samplers will be used to sample riffle/run areas of creeks and pool habitats at creeks, ponds, and seeps. A Surber sampler with a 1 square-foot (0.09 m^2) frame and 352 micrometer mesh net will be used to sample shallow creek stations (riffle/run areas) where the substrate is primarily sand/gravel and flow is sufficient to carry the macroinvertebrates into the net. Triplicate samples will be taken within the 50-meter creek segment, working upstream. Each replicate sample will be transferred directly into a plastic sample container and preserved in 70 percent isopropanol or 10 percent formalin.

At pool habitats in creeks, and at the pond and seep stations, triplicate samples will be collected with an Ekman grab sampler. A pole-mounted sampler will be used at most or all sample stations, providing a more uniform depth sample. A rope-suspended sampler triggered with a messenger will be used at stations that are too deep for the pole-mounted sampler. Each triplicate sample will be transferred from the sampler to a field wash bucket with a No. 30 sieve mesh or smaller, washed thoroughly, and then placed into a sample container and preserved. Large rocks or twigs can be discarded during the washing process after organisms are hand picked or washed into the bucket with a water spray.

Qualitative samples of CPOM will be collected at stations where there are substantial quantities of plant debris. Several handfuls of leaves, twigs, and/or grass will be placed into the sample containers and labeled as a qualitative CPOM sample. The benthic organisms will be picked from this debris in the laboratory and the number of individuals in each Functional Feeder Group (EPA, 1989d) will be recorded. Organisms in these samples may not be identified to genera because the principal objective is to assess the proportion of scrapers, filterers, and shredders at the sample station.

Benthic macroinvertebrates will be collected at two downgradient stations on Women Creek and South Walnut Creek for tissue analysis to determine if inorganic and radionuclide contaminants

may be accumulating in the tissue of the dominant species. Samples will be collected with dip nets, kick nets, and/or Surber and Ekman samplers. Sampling will continue until a sufficient biomass of some of the dominant species are obtained for laboratory analysis. The samples may be washed in the field, then placed in sample containers and kept on ice. The organisms will be picked from the sample in the laboratory, kept at or near 4°C. Samples will be shipped to the analytical laboratory within 48 hours of collection or frozen and shipped at a later time.

The flow conditions and other physical and biological characteristics of the sampling station will be documented in the field log. Field instruments will be used to collect basic water quality data (see Subsection C.4.2.1). Qualitative statements regarding the occurrence of periphyton, algae, amphibians, and fish will be recorded. All samples will be numbered and labeled as they are collected.

Sample Preparation/Analysis

Benthic macroinvertebrate samples will be processed in the laboratory by rinsing the sample in fresh water (U.S. Standard No. 60-mesh screen) and transferring the sample to a shallow white tray. Benthic organisms will be separated from the debris with forceps, using a table-mounted magnifier, and placed into sample vials of 70 percent ethanol. The samples will be analyzed by identifying the organisms to genus (with some exceptions such as chironomids) and counting the number of individuals in each taxon. Identification and enumeration will be made using dissecting microscopes.

Ecological Endpoints

Benthic macroinvertebrate samples at each station will be analyzed for genera present, species diversity, total number of organisms by taxa, and the proportion of pollution-tolerant or pollution-sensitive taxa. The relative abundance of scraper, filter collector, and shredder Functional Groups will also be determined (EPA, 1989d).

The data from quantitative samples will be used to determine macroinvertebrate density (standing crop), taxa richness, species diversity, ratio of scraper and filtering collector functional feeding groups, ratio of pollution tolerant and pollution sensitive taxa, and community similarity indices.

Equipment

The field equipment required for benthic macroinvertebrate sampling includes the following:

- Field data sheets and field logbook
- Surber and Ekman samplers
- Benthic wash buckets
- Boots and waders
- Sample containers, labels, and preservatives
- Boat and oars, anchor and life preservers
- Water quality field instruments
- Cooler and ice
- Decontamination equipment
- Instrument calibration standards.

C.4.1.3 Fish

Fish communities will be sampled at five creek stations within OU No. 2, at a reference station on Rock Creek or the upper end of Woman Creek, and at ponds along Woman Creek and South Walnut Creek (Table C.1 and Figure C-1). Fish will be collected by electroshocking from similar sized creek segments or shoreline areas, using procedures that will yield catch-per-unit-effort results. All fish will be identified and counted. Water quality data will be collected in association with the sampling effort. The physical characteristics of each sampling location will be documented to assess the influence of physical features on fishing success and the types and abundance of fish present.

Location/Frequency

Fish communities will be sampled at nine stations within OU No. 2 and at one or more reference stations (Table C.1). The two ponds on Woman Creek (C-1 and C-2) and the two lower ponds on South Walnut Creek (B-4 and B-5) will be sampled. The upper three ponds on South Walnut Creek will not be sampled because they are off-channel ponds used to control spills (B-1 and B-2), or to contain and control surface runoff and the discharge from the sanitary wastewater treatment plant at the RFP (Pond B-3). Since flow along Woman Creek downgradient of Pond B-3 goes through Ponds B-4 and B-5, sampling of these two ponds should provide adequate assessment data.

Since there are very limited running water habitats along South Walnut Creek, no creek stations will be sampled. On the South Interceptor Ditch and Woman Creek, sample stations will be located at the upper and downgradient areas of the operable unit (Table C.1 and Figure C-1). Sampling results from the four on-site creek stations will be compared to the off-site reference station offsite.

The sample stations for fisheries work will be the same 50-meter creek segments or 50-meter shoreline areas used for benthic sampling. Fish will be collected from all stations during the late Spring-early Summer period and again in late Summer-early Fall. All fish will be released back to the creek or pond except for a limited number of reference specimens, small fish that cannot be identified in the field, and individuals collected for tissue analysis. Precautions will be taken so that the sampling effort itself does not produce an impact on fish populations. Fish kept for identification or reference will be preserved in 70 percent ethanol or 10 percent formalin, and fish kept for tissue analysis will be put on ice.

Field Methods

Fish will be collected from the 50-meter stream segment stations by setting blocknets at each end of the station and making two or three collection passes with a backpack electroshocker. Fish will be removed from the creek with long-handled dip nets and placed in live tanks. The mesh size on the dip nets will be determined during the qualitative field survey effort so that adult fish and most juveniles are retained in the net. A standard sampling time of 20 to 30 minutes will be established while sampling the first two stations. The same shocking time will be used at all stations. While the stream is still blocked, short seines or dip nets will be used after shocking to check deep holes and shoreline pockets.

Fish samples will be processed immediately after shocking is completed. All fish will be identified, counted, and measured (total length to the nearest mm). Dominant species will also be weighed. As stated above, most fish will be released back to the creek. Data will be recorded on standard field data sheets. Small individuals may be kept for identification in the laboratory.

At the pond stations, fish will be collected by shocking along 50-meter portions of the shoreline. Since it is impossible to use block nets for pond sampling, repeated passes along the same shoreline segment would be unproductive, so several 50-meter areas may be sampled if fishing success is poor. Pond sampling may be more productive during the late afternoon or evening.

The physical characteristics of each sampling station will be described in the field log and conditions which may influence catch success will be recorded. Basic water quality measurements will be taken with field instruments at each sampling station.

Sample Preparation/Analysis

Fish samples will be processed in the field, allowing most fish to be released alive. Fish specimens retained for reference or identification will be preserved and labeled. Fish kept for tissue analysis will be kept on ice in labeled plastic bags and processed within 24 hours of collection. If possible, minnows and/or sunfish will be collected for tissue analysis at all stations. Large fish of other species, such as bullheads, will be kept if more biomass is needed for analysis. The larger fish will be filleted and the right and left fillets will be wrapped separately in aluminum foil, labeled and frozen. Catfish and bullheads will be skinned. Each fish will be divided along the backbone so that the right and left sides can be wrapped and frozen separately. Smaller fish selected for tissue analysis will be cleaned and frozen whole. Right and left fillets can be used as duplicate samples and/or submitted to different laboratories for inorganic and radionuclide analyses.

Ecological Endpoints

All fish will be identified, counted, and measured. The fisheries data will be analyzed for relative abundance, catch-per-unit-effort statistics, length-frequency histograms, and the relative proportions of herbivorous, carnivorous, or omnivorous species.

Equipment

The field equipment required for fisheries sampling includes the following:

- Field data sheets and field logbook
- Backpack electroshocker
- Measuring board and scales

- Boots and waders
- Sample containers, labels, and preservatives
- Boat and oars, anchor and life preserver
- Water quality field instruments
- Cooler and ice
- Decontamination equipment
- Instrument calibration standards
- Fish identification keys and hand lens

C.4.2 TERRESTRIAL ECOSYSTEMS

The FSP for terrestrial communities is directed at sampling include grasslands, wetlands, small mammals, invertebrates, and roots at selected locations at the source areas and stations east of the source areas. A reference area or areas selected for comparative studies will be sampled for similar components and parameters. The stations selected for terrestrial sampling are shown in Figure C-2 while the sampling program is summarized in Table C.2. The station location or the selection of the component being sampled may be modified to be consistent with the results of the Spring qualitative survey and to correspond to surficial soil sampling locations.

C.4.2.1 Grassland Vegetation

The grassland community at the reference and test areas will be sampled for plant species cover and productivity using standardized quadrats. These parameters give the best indication of the structure and function of dryland vegetation. A preliminary field reconnaissance of the site did not reveal significant areas of other vegetation types. There are no shrubland or woodland types of a size sufficient to sample. The isolated shrubs or single trees will be noted or sampled within the quadrats selected for grassland sampling.

Location/Frequency

Grassland vegetation will be sampled at the 11 stations shown on Figure C-2. These will be staked and located to represent the grassland type in the vicinity of the location selected. Sample locations will be determined during the qualitative field surveys by ground truthing and with the use of maps and aerial photographs. The locations will also be used for sampling small mammals, roots, and invertebrates. Within the sampling area, one-square-meter plots for cover and quarter-square-meter clipping plots will be located using a random stratified method. The

TABLE C.2

TERRESTRIAL FIELD SAMPLING PROGRAM FOR VEGETATION, SMALL MAMMALS, AND WETLANDS OPERABLE UNIT NO. 2

Component	Parameter	Sampling Period	Station
Grassland	Cover by species Productivity Tissue analysis	Early Summer Late Summer	TS-1 to TS-11
Small Mammals	Species Density Tissue analysis	Early Summer Late Summer	TS-1 TS-2 TS-6 TS-9 TS-10
Roots	Tissue analysis	Late Summer	TS-1 to TS-7 TS-9
Invertebrates	Species Tissue analysis	Early Summer	TS-1 to TS-11
Wetlands	Species Dominance Tissue analysis	Late Summer	WS-1 to WS-9

area will be gridded and a spot on the grid selected using a random number generator. Quadrat locations may be rejected for being disturbed or not representative of the vegetation in the area.

Grassland will be sampled during two periods: an early season sample during late Spring/early Summer and a late season sample during the late Summer. Cool-weather grasses and early season forbs will be sampled during the first sampling period. Warm-season grasses and late-season forms will be sampled during the latter period.

Field Methods

Two sizes and types of quadrats will be used: one-square-meter plots for cover and quarter-square-meter plots for current season productivity. In the one-square-meter plots, the cover of each plant species will be visually estimated to the nearest percent and notes made on condition and phenology. The quarter-meter plots will be clipped according to the current season's growth by species or type of species and bagged for dry weight and tissue analysis. The number of

quadrats for both cover and productivity will be determined by a sample adequacy formula. There will not be less than 15 quadrats for each type.

Sample Preparation/Analysis

The cover quadrats will be analyzed for species composition and cover, and the frequency and dominance (importance) values derived. The sample clipped for productivity will be oven dried to a constant weight and weighed. Additional samples will be collected and analyzed for tissue concentrations of a standard list of inorganic chemicals, and radionuclides. The analytical parameters are listed in Section C.5.4.

Ecological Endpoints

The grassland quadrat sample will provide species composition, cover, productivity, diversity, and structure of the terrestrial ecosystems. Tissue sample analysis will provide information on concentrations of contaminants in vegetation as an indication of bioaccumulation.

Equipment

Equipment to be used for grassland sampling includes:

- Field forms for recording cover and clipping plots data
- Metric rulers
- One- and 0.25-meter-square frames
- Clippers
- Paper sacks and indelible marker
- Plastic bags
- Cooler and ice.

C.4.2.2 Small Mammals

Small mammals will be trapped live at the reference areas and at some of the same locations as the grassland plots. Small mammals, particularly microtines, will be trapped because they are primary consumers of vegetation and form the basis for the link to higher levels in the food chain leading to top carnivores. Mice and ground squirrels will be trapped because they live on and in the soil; they may be directly exposed to contaminants.

Location/Frequency

Small mammals will be trapped at five of the 11 sampling locations shown on Table C.2. These locations may be modified, based on results of the qualitative field surveys conducted in the late Spring. There will be two trapping periods, the first in mid-June for early season densities, and one in late August to determine changes in densities from the season's reproduction.

Field Methods

Live traps will be laid out in a five-trap by ten-trap grid at 10-meter intervals for a total of 50 traps. The traps will be run for four consecutive nights at four-hour intervals. Animals trapped will be recorded for species, weight, sex, and breeding condition. They will be released alive. At the end of the trapping period, a number of individual animals will be collected and preserved for tissue analysis. A representative sample will be determined from the trapping results. Animals selected for tissue or organ analysis will be asphyxiated, placed in plastic bags, and stored on dry ice for transport to the laboratory for analysis.

Sample Preparation/Analysis

The animals will be prepared according to laboratory procedures established for the type of analysis to be conducted. Animals selected for organ analysis will be dissected prior to tissue analysis.

Ecological Endpoints

The small mammal populations will be analyzed for species, density, and reproductive success. These parameters will be indicative of the condition of this important trophic level.

Equipment

Field equipment that will be used for small mammal trapping includes:

- Field data sheets for recording sampling information
- Sherman or equivalent live traps
- Plastic bags
- Field scales in grams to the nearest gram
- Cooler and dry ice.

C.4.2.3 Roots

Roots for tissue analysis will be collected in hand-dug trenches to a depth (probably about 0.5 meter) determined during the qualitative surveys of rooting depths and density. Collection will occur once during the late Summer growing season at the station indicated in Figure C-2 and listed in Table C.2. Roots will be collected from the sides of the trench for the equivalent of about 100 grams of root material from incremental depths of 10 centimeters to the bottom of the trench. They will be placed in plastic bags, stored in a cooler with ice, and transported to the laboratory for tissue analysis. The tissues will be analyzed for the contaminants listed in Section C.5.4. The ecological endpoints for the root tissue sample analysis is to determine possible amounts of transport to vegetation shoots from root uptake of contaminants.

C.4.2.4 Invertebrates

Invertebrates, mostly insects, will be collected at all vegetation sampling locations by the use of sweep nets. Sweeps will be accomplished by making approximately 20 strokes at the top of the vegetation canopy. The material caught in the net will be placed in killing jars, stored in vials, and transported to the laboratory for analysis. Ground-dwelling arthropods will be picked up by hand and handled in the same manner as invertebrates caught in the sweep nets. The ecological endpoints of the invertebrate sampling is a compilation of common species of an important ecosystem component.

C.4.2.5 Wetlands

Wetlands will be sampled because they are an important and productive vegetation type although small in size and extent. The wetlands at OU No. 2 grow around seeps on the slopes below the source areas and along drainages and ditches. Wetlands will be characterized for location, size and condition, and sampled in late Summer for dominant species present. Samples will be taken of major plant species for tissue analysis. The growing shoots will be clipped and handled in the same manner as the grassland samples. The ecological endpoint of the wetland sampling is a determination of whether wetland plant tissues bioaccumulate contaminants in surface water from underground springs and seeps.

C.5.0 QUALITY ASSURANCE/QUALITY CONTROL

The basic quality assurance/quality control (QA/QC) protocols for the ecological assessment at OU No. 2 are incorporated into this EEW and in existing QA/QC documents for the Environmental Restoration Program at RFP. However, many of the OU-specific QA/QC protocols will be presented in project reports that will be prepared prior to implementing the field sampling. For example, data quality objectives and the basic QA/QC protocols for the field sampling will be presented in an OU-specific Quality Assurance Project Plan (QAPP). Also, sample management and waste management protocols, as well as details of laboratory analytical requirements, will be prepared after the EEW is approved. This section of the FSP addresses some of the QA/QC issues and indicates the general QA/QC protocols that will be developed and used for the EE.

C.5.1 SAMPLE DOCUMENTATION

Standard procedures will be developed to document sampling activities and conditions. Standard procedures will also be used to label and track field samples. Bound field logbooks will be used to document field activities and sampling conditions. Standardized data sheets will be used for the different sampling activities so that complete data records are maintained. The sampling leader and team will be recorded for each day. Entries in the logbook and data sheets will allow the sampling team leader to recreate sampling details at a later date if necessary. All sampling locations will be described.

A sample management plan will be developed to: control sample labeling; provide a numbering system to track individual samples in the field and laboratories, and in the data management system. Chain-of-custody procedures for both chemical and biological samples will be established. The sample management plan will be integrated with the ongoing RFI/RI activities at OU No. 2.

C.5.2 EQUIPMENT CALIBRATION AND CHECKS

All equipment will be checked prior to field work, on a daily basis when necessary, to assure that all equipment components are in place and that the equipment is operating properly.

Manufacturer's operating manuals and calibration procedures will be followed for field instrumentation (e.g., pH meters and photoionization detectors). Calibrations for the appropriate instruments will be made on a daily basis. A system for flagging defective equipment to preclude its use will be developed.

Equipment lists will be maintained for all sampling activities so that field crews are adequately and completely equipped. Also, only qualified operators will be used to operate field instruments and equipment such as fish electroshockers.

C.5.3 HEALTH AND SAFETY/WASTE MANAGEMENT

Health and Safety (H&S) Plans will be prepared for each sampling activity or field effort. Field crews will be informed of potential hazards associated with the site area and with sampling operations. The H&S Plan will address both physical and chemical/radiological hazards and include medical emergency protocols and contracts.

A waste management plan will be developed to describe procedures required to decontaminate equipment and personnel before and after sampling activities. The plan will describe procedures for handling potentially toxic or radioactive waste appropriately. Further, the plan will describe waste characterization/classification protocols and waste handling and segregation procedures. The plan will also address packaging and labeling of wastes and transferring sample-generated wastes to the proper on-site storage or disposal areas.

C.5.4 SAMPLE HANDLING AND ANALYTICAL PROTOCOLS

Sample management plans and laboratory analytical protocols will be developed to establish standard procedures for handling, preserving, and shipping samples. The protocols will also address methods of communicating analytical requirements to the laboratories.

For the bioaccumulation study, tissue samples from terrestrial and aquatic organisms will be kept on ice and shipped to the laboratory within 24 to 48 hours of collection, or frozen and shipped to the laboratory at a later time. Tissue samples will be analyzed for the following inorganics (metals) and radionuclides:

Metals		Radionuclides
Aluminum	Magnesium	Uranium 223, 234, 235, 238
Antimony	Manganese	Americium 241
Arsenic	Mercury	Plutonium 239, 240
Barium	Molybdenum	Strontium 89, 90
Cadmium	Nickel	Tritium
Calcium	Potassium	
Chromium III	Selenium	
Chromium IV	Silver	
Copper	Sodium	
Iron	Strontium	
Lead	Vanadium	
Lithium	Zinc	

These inorganic elements and radionuclides have been detected at the 903 Pad, Mound, and East Trenches during the Phase I RFI/RI. The holding times, preservation methods, and approximate sample sizes required are presented in Table C.3. Metals will be determined by inductively coupled argon plasma spectroscopy (ICP) or graphite furnace atomic absorption spectroscopy (GFFA). GFFA is required to attain the lower detection limits needed to assess risks for the more toxic and/or carcinogenic inorganics. The detection limits will be established during development of the QAPP and data quality objectives.

Tissue samples will not be analyzed for organics. The principal organic contaminants at OU No. 2 are volatiles, and these compounds will normally volatilize fairly quickly from surface water, air, and surficial soils that are the most common exposure points for living organisms. Also, the laboratory protocols for tissue digestion and analysis frequently do not provide good quality consistency or reproducible results for volatile organics unless extreme care is taken in handling and processing the samples. Therefore, bioaccumulation studies will be limited at present to inorganics and radionuclides.

TABLE C.3

HOLDING TIMES, PRESERVATION METHODS, AND SAMPLE CONTAINERS FOR BIOTA SAMPLES

Samples for Metal Analyses	Maximum Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size
Terrestrial Vegetation				
Metals Determined by ICP**	6 mos	Freeze and ship with dry ice	Paper bag inserted into plastic bag and sealed	25 g
Metals Determined by GFAA**	6 mos	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	25 g
Hexavalent Chromium	24 hours	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	25 g
Mercury	28 days	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	5 g
Periphyton and Benthic Macroinvertibrates				
Metals Determined by ICP	6 mos	Freeze & ship w/dry ice	Plastic	25 g
Metals Determined by GFAA	6 mos	Freeze & ship w/dry ice	Plastic	25 g
Hexavalent Chromium	24 hours	Freeze & ship w/dry ice	Plastic	25 g
Mercury	28 days	Freeze & ship w/dry ice	Plastic	5 g

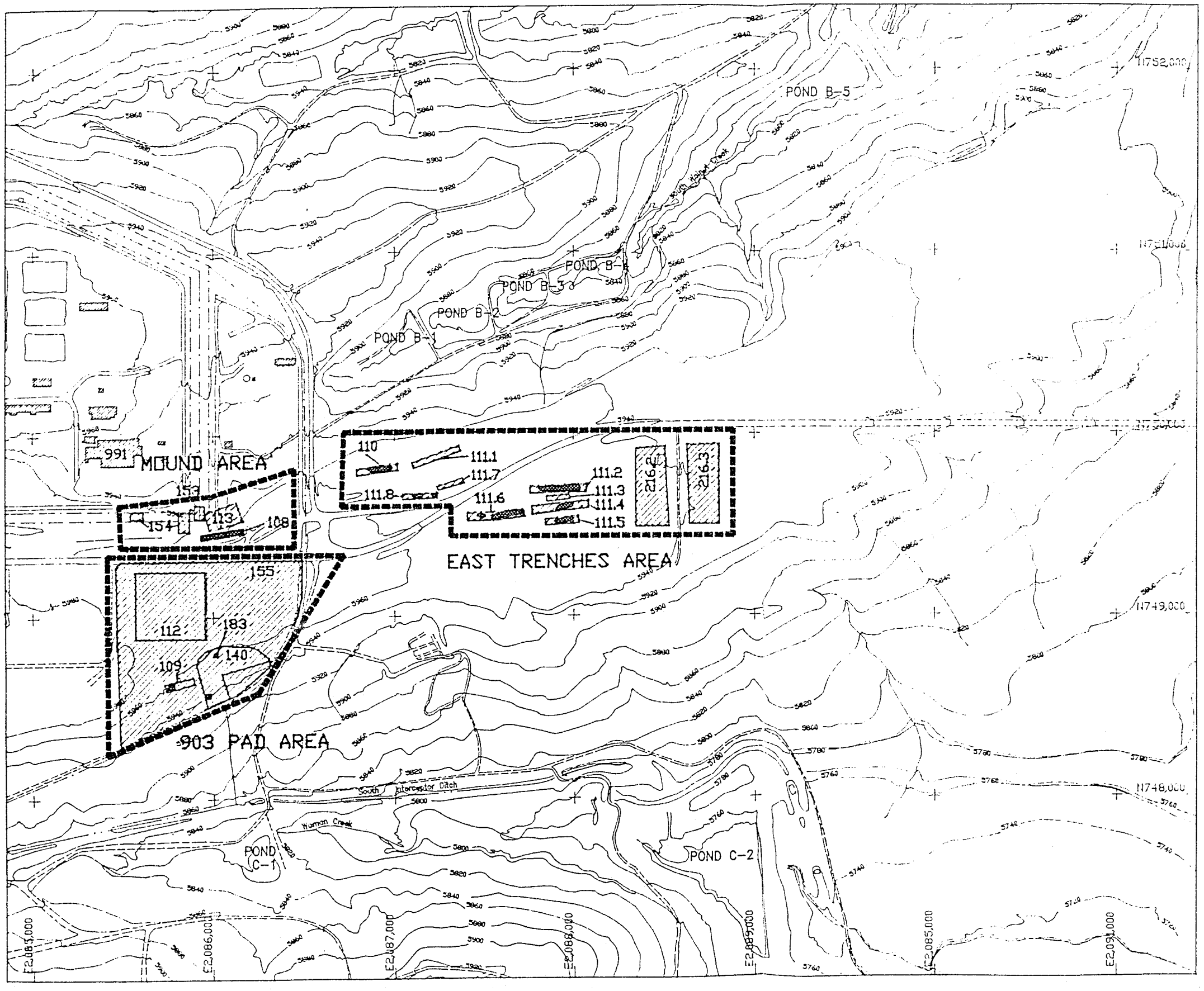
Samples for Radionuclide Analyses	Maximum Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size
Terrestrial Vegetation				
Uranium 223, 224, 235, 238 Americium 241 Plutonium 239, 240 Tritium Strontium 89, 90	6 mos	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	1 kg
Periphyton and Benthic Macroinvertebrates				
Uranium 233, 234, 245, 238 Americium 241 Plutonium 239, 240 Tritium Strontium 89, 90	6 mos	Freeze & ship w/dry ice	Plastic	1 kg

* Sample size may vary with specific laboratory requirements.
** ICP = Inductively Coupled Argon Plasma Emission Spectroscopy.
+GFAA = Graphite Furnace Atomic Absorption Spectroscopy.

The sample management plan and laboratory analytical protocol document will specify the type and number of QA/QC samples required in the field and in the laboratory. For example, duplicate field samples will normally be collected at a rate of at least one duplicate sample per 10 field samples. Various types of field blanks will also be collected or prepared to verify equipment decontamination or check on extraneous sources of contamination. The QA/QC samples required for laboratory processing (e.g., laboratory duplicates, spiked samples, and blanks) will be specified in the laboratory analytical protocols.

C.5.5 STATISTICAL ANALYSIS AND PROCEDURES

Standard statistical methods and procedures will be used to analyze data collected in the quantitative sampling program. Where appropriate, data will be analyzed for the statistical parameters of means, variances, and standard deviation to determine precision of values. Normally distributed data will also be analyzed for variances and correlation coefficients or regression analysis to determine, for example, if contaminant concentration in tissue is related to media contaminant concentration. Significant differences in paired samples between locations or sampling periods will be established, such as comparisons between reference areas and the test area sample data. Sample adequacy formula will be used to determine if the number of samples is adequate based on mean, variance, and the level of accuracy needed. Since much of the data used to characterize the biological parameters are simply descriptive, values such as the arithmetic mean, maximum, and minimum will be reported for many samples.



EXPLANATION

216.2 — SOLID WASTE MANAGEMENT UNIT (SWMU) AND SWMU DESIGNATION

REMEDIAL INVESTIGATION AREAS

N

Scale: 1" = 600'

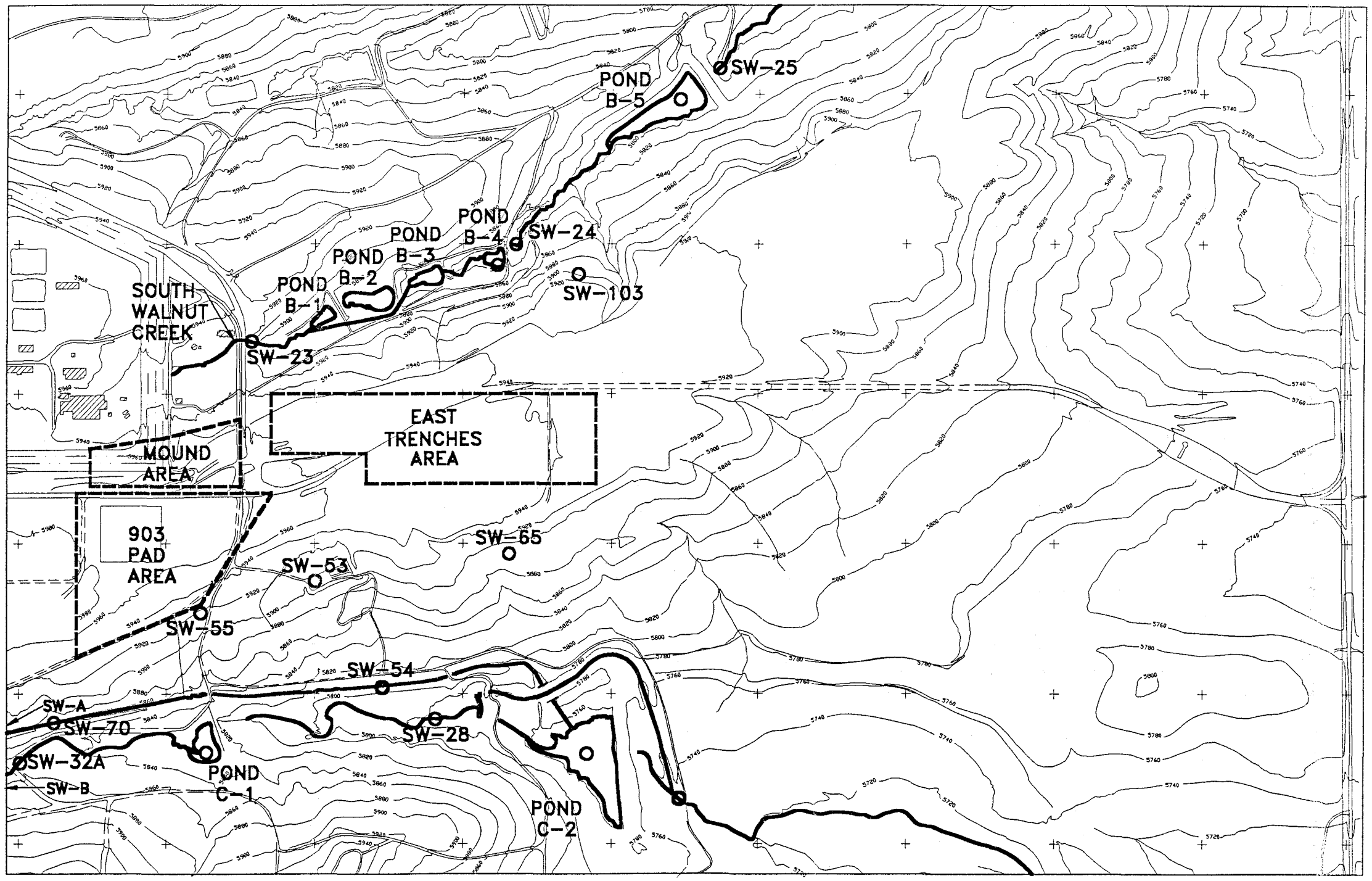
0' 300' 600'

CONTOUR INTERVAL = 20'

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 1
OPERABLE UNIT NO. 2
903 PAD AREA, MOUND AREA, AND EAST TRENCHES AREA

DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
KRONER 10-31-90	RPH 11-2-90	RPH 11-2-90	304937-B6



EXPLANATION

SOURCE AREAS

SW-1
O
SAMPLING STATION

SCALE
0 800 1600 FEET
CONTOUR INTERVAL = 20'

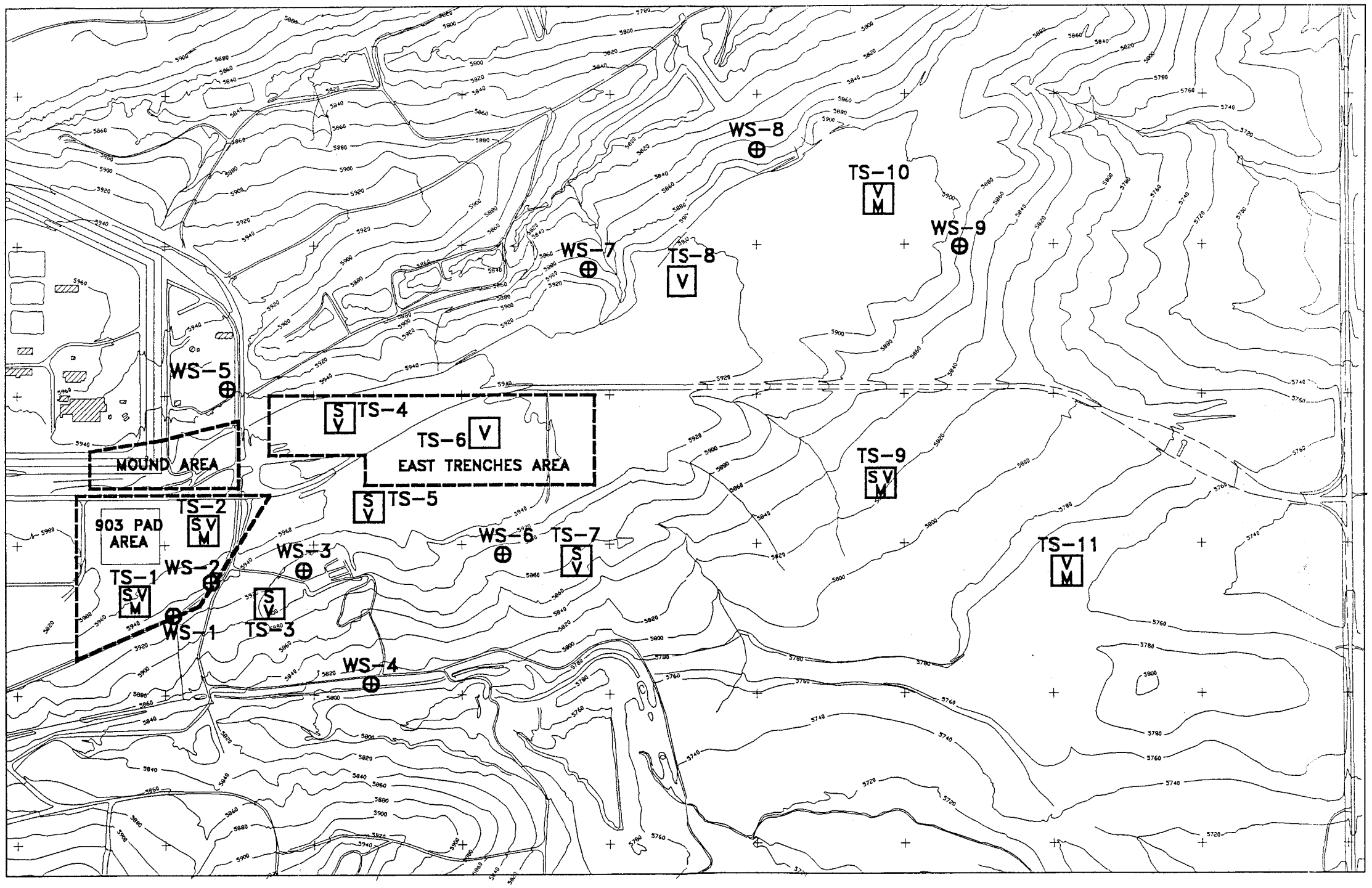
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

OPERABLE UNIT NO. 2
ENVIRONMENTAL EVALUATION
WORK PLAN

FIGURE C-1

AQUATIC ECOLOGY
SAMPLING STATIONS

DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
KRONER 10-31-90	RPH	RPH	304937-B5
	11-1-90	11-2-90	



EXPLANATION

SOURCE AREAS

TS-1 TERRESTIAL SAMPLING LOCATION

V – GRASSLAND VEGETATION PLOTS

M – SMALL MAMMAL TRAPPING STATION

S – SOIL ROOT SAMPLING LOCATION

⊕ WETLAND SAMPLING LOCATION

SCALE

0 800 1600 FEET

CONTOUR INTERVAL = 20'

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

OPERABLE UNIT NO. 2
ENVIRONMENTAL EVALUATION
WORK PLAN

FIGURE C-2

TERRESTRIAL AND WETLAND
SAMPLING STATIONS